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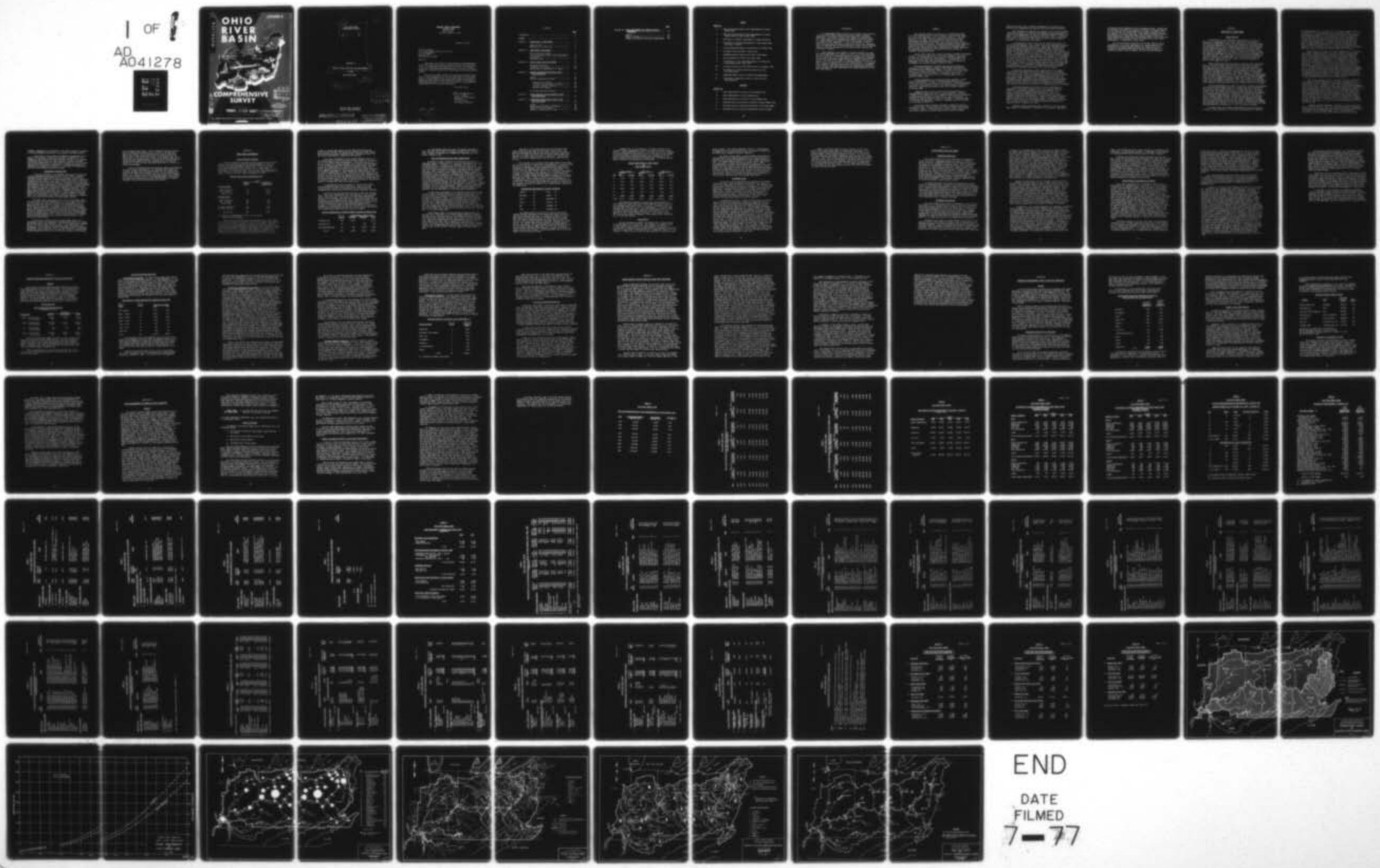

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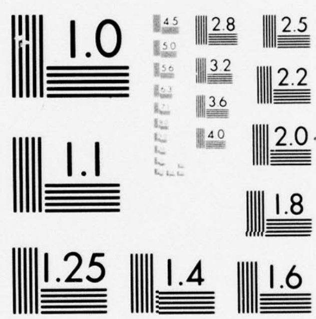

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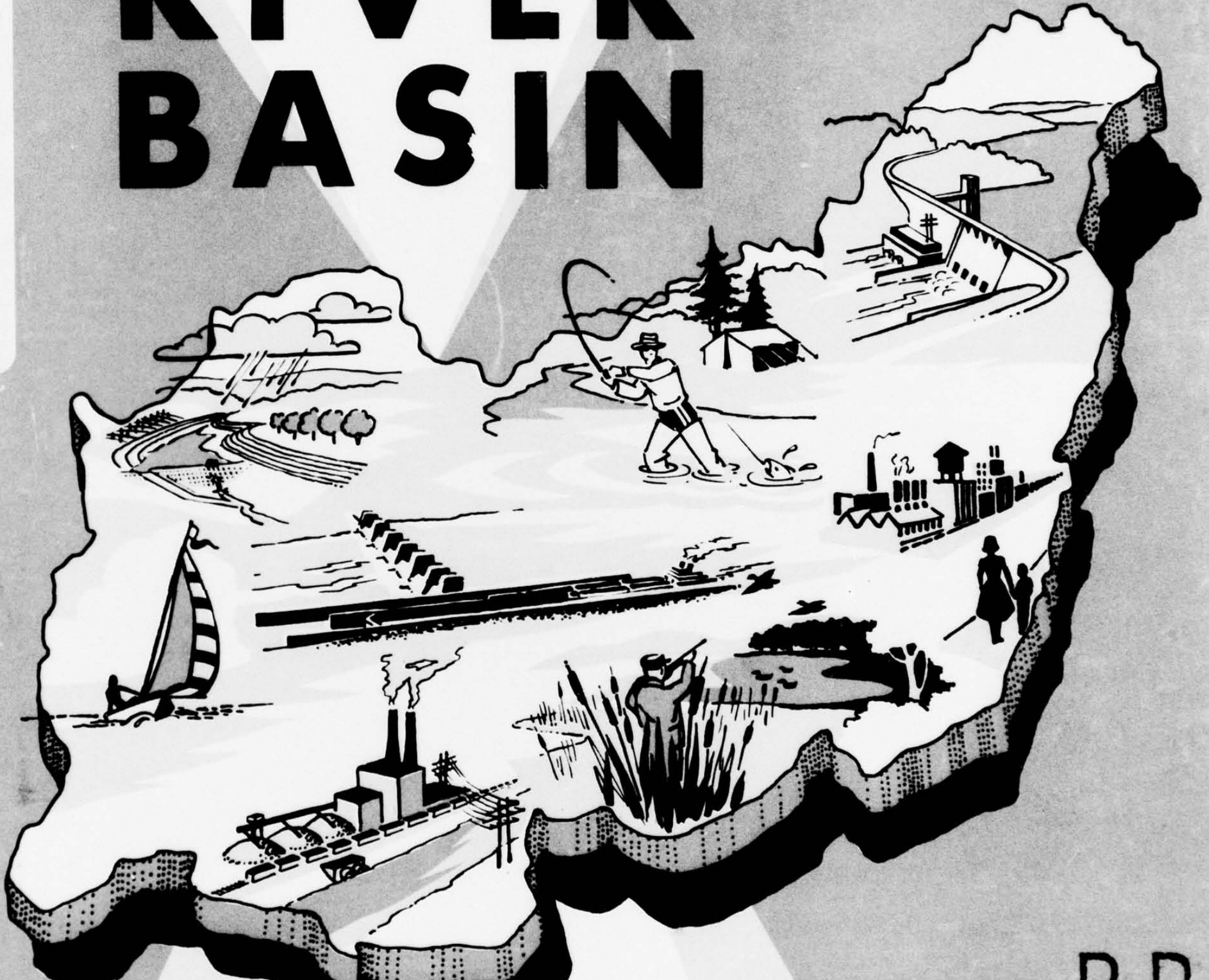

COMPREHENSIVE SURVEY

Prepared by
the Federal Power Commission
in cooperation with Departments
of Agriculture; Army; Commerce;
Health, Education and Welfare; Interior
and participating states.

APPENDIX I

FORMAL REVIEW DRAFT

ELECTRIC POWER

U.S. ARMY ENGINEER DIVISION, OHIO RIVER-CINCINNATI, OHIO

(6) (1)

OHIO RIVER BASIN
COMPREHENSIVE SURVEY.

Volume X.

APPENDIX I.

ELECTRIC POWER RESOURCES AND REQUIREMENTS.
IN THE
OHIO RIVER BASIN

(12) 92p.

(11) 1966

Federal Power Commission
New York Regional Office

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FEDERAL POWER COMMISSION
REGIONAL OFFICE
346 Broadway
New York, New York 10013

December 16, 1966

Division Engineer
U. S. Army Engineer Division, Ohio River
Corps of Engineers
P.O. Box 1159
Cincinnati, Ohio 45201

Dear Sir:

This report on the Electric Power Resources and Requirements in the Ohio River Basin has been prepared by the New York Regional Office of the Federal Power Commission for inclusion as Appendix "I" in the Ohio River Basin Comprehensive Survey. The report has been prepared in cooperation with other federal agencies and participating states.

The report provides information on past and estimated future electric power requirements of the Ohio River Basin and contiguous areas to the year 2020, as well as pertinent data on existing power generating facilities and those definitely planned for the future, undeveloped hydroelectric power resources and water requirements for thermal generation in the Ohio River Basin.

Sincerely yours,

John H. Spellman
John H. Spellman
Deputy Regional Engineer
FPC Member
Ohio River Basin
Coordinating Committee

Letter on file

A

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INTRODUCTION

A comprehensive survey of the water and related land resources of the Ohio River Basin involves among other things a thorough examination of the area's electric power supply and requirements. The economic well being and industrial progress of the Basin depend in no small measure on an adequate and economic supply of power for its population and industries. In turn the production of electric power from steam and hydroelectric plants may involve the consumptive and non-consumptive use of large quantities of water, and is therefore among the principal purposes which the Basin's water resources are called upon to serve.

Power Appendix I was prepared to provide information on past and future requirements of a market for power in the Ohio River Basin which is served in a coordinated manner by a group of interconnected electric utilities and the characteristics and magnitude of existing and probable future power supply facilities required to serve this market. The area of the market is slightly different than that of the Basin, but is one appropriate for power study purposes. The Appendix also includes a complete accounting of all existing and anticipated future electric power generating facilities, undeveloped hydroelectric power resources and water requirements for thermal generation in the Ohio River Basin.

SUMMARY

This Appendix presents the results of a comprehensive study of the use and production of electric energy in the Ohio River Basin and of the vital dependence of its electrical industry on the water resources of the area. Past and estimated future electric power requirements and supply were examined for a selected market which was considered appropriate for power study purposes and which covers nearly 90 percent of the Basin. Existing and expected future generating facilities by type of prime mover, developed and undeveloped hydroelectric power resources, and water requirements for thermal generation are presented and examined for the Basin as a whole and for its component tributary sub-basins.

The Ohio River Basin has a highly developed and widely diversified economy. The area produces most of the coal consumed in the nation, is noted for the variety and concentration of its basic industries, and is of national importance agriculturally. Indispensable to the development of the Basin and its sustained growth in the future is an abundant and economical supply of electric power.

The market employed in the study was selected primarily on the basis of utility physical makeup, areas served, and operating relationships with neighboring systems. This market does not conform exactly to the Basin boundaries. Electric service in the market also is provided by 318 utility systems, 282 publicly owned and 36 privately owned. Ten percent of the total number supply about 95 percent of market load.

Energy requirements of the selected market amounted to 120.2 billion kilowatt-hours in 1963. Associated peak demand was 19.7 million kilowatts at a load factor of 69.6 percent. These are estimated to increase to 316 billion kilowatt-hours and 54 million kilowatts in 1980 and to 1,726 billion kilowatt-hours and 291 million kilowatts in the year 2020.

Industrial sales of more than 70 billion kilowatt-hours in 1963 represented almost 60 percent of total deliveries to ultimate consumers in the market area. The industrial sales include the delivery of approximately 23 billion kilowatt-hours to the Atomic Energy Commission's gaseous diffusion plants in the Basin. Industrial needs of the market are expected to continue to represent more than one-half of total sales through 1980.

Generating capacity serving the market totalled 25.1 million kilowatts in 1963. Of this amount 24.1 million kilowatts were located in the Basin proper. Thermal generation, mostly steam, accounted for 24.8 million kilowatts of market capacity with only 343 thousand

kilowatts in hydro units. Backbone transmission in the market is at 345 kilovolts, supplemented by extensive 138 and 69 kilovolt networks.

After allowance for estimated retirements of 2.4 million kilowatts of generating capacity by 1980 and known planned additions subsequent to 1963, it is estimated that the need for additional capacity to serve the market load in 1980 will be 42.5 million kilowatts. Most of this would be located in the Ohio River Basin with only three million kilowatts expected to be installed in other basins.

In the Basin as a whole, total electric generating capacity at the end of 1963 amounted to 31.7 million kilowatts, including 2.5 million in non-utility industrial power plants. Three large Tennessee Valley Authority plants, located outside of the market area, accounted for nearly four million kilowatts of the Basin's capacity. More than 95 percent of the 1963 capacity is in conventional, coal fired, steam-electric units. A substantial portion of this is in "mine-mouth" plants, a concept that has been developed to a high degree in the area due to the abundance of low cost coal. For the Basin as a whole the average cost of coal was 19.2 cents per million Btu's in 1963. For some plants it was less than 15 cents. There are two nuclear generating stations in operation in the Basin. While the bulk of future thermal capacity additions through 1980 is estimated to be in conventional steam-electric units, the amount of nuclear generation is expected to increase substantially thereafter, especially in peripheral areas distant from the coal fields.

Conventional hydroelectric power installations in the Basin totalled about one million kilowatts in 1963. Most of the existing hydro capacity is located in the Cumberland River Basin and is utilized on the load of TVA. There were 400 megawatts under construction at five sites in 1963, including one at a federal navigation dam. Such developments offer significant additional benefits at multiple-purpose projects along the main stem and major tributaries of the Ohio River. The current ratio of hydro to total utility capacity in the Basin of less than four percent is not expected to change materially in the future.

Undeveloped hydroelectric power in the Ohio River Basin is estimated at 7.6 million kilowatts of which 4.7 million kilowatts would be in conventional installations and the remainder of 2.9 million kilowatts in pumped-storage developments. Most of the potential conventional installations would be located at federal navigation dams along the main stem of the Ohio River and at multiple-purpose reservoirs on its tributaries. Based on projects currently under construction and in the planning stage, it is expected that more than two million kilowatts of the Basin's undeveloped hydroelectric capacity will be in operation by 1980.

Available surface and ground water resources in the Ohio River Basin appear to be sufficient to satisfy the cooling water requirements

of thermal electric generation in the foreseeable future. Conventional once-through cooling will be adequate for the bulk of thermal capacity to be in operation on the main stem and principal tributaries of the Ohio River in the next 15-20 years. Thus, based on assumed composition and distribution of 1980 power supply some 50 million kilowatts of steam capacity will obtain their cooling water needs in the conventional manner, while the remaining 25 million kilowatts will require water impoundments, or evaporative cooling towers.

For the more distant future such as the year 2000 and beyond an evaluation of the water requirements for thermal generation is difficult and uncertain because neither the composition nor the location of the future generating facilities can be estimated to a satisfactory degree even for general and broad planning purposes.

SECTION I

DESCRIPTION OF POWER MARKET

Region Economy

Consideration of the availability and utilization of electric power and its relationship to the water resources of an area is a necessary and significant phase of any comprehensive river basin survey. The large scale generation of electricity involves the consumptive and non-consumptive use of water in substantial quantities and is therefore of great importance among the various purposes which an area's water resources may be called upon to serve. The role of electricity in the past growth of a region and its probable contribution to future economic and industrial development are key factors in the overall assessment of regional potential. The relationship of the various factors defining a region's economy is an interdependent one. The proper appraisal of electric power must be made in the context of the total economy of which it is so important a part.

Usage of electricity may be broadly considered as that associated with (1) the direct needs of the population in the home and essential services; (2) the natural resources of an area and industries that have developed due to the existence of these resources. Electric power consumption increases directly with rising standards of living, higher income and technological progress. This applies equally to domestic, commercial and other classes of service. Just as new uses for electricity are continually being found in the home and in trade and service establishments, so also is greater utilization being made of this form of energy on the farm, and industry in general. Thus, the availability of electric energy is a key element in the economy of a region, and in turn the electric power industry is directly affected by the economic vitality of the area.

The Ohio River Basin is a region of economic contrasts and diversity. Covering over 160,000 square miles, it produces more than 70 percent of the country's coal, contains some of the richest farm land to be found anywhere, has the largest concentration of heavy industry of any sector of the nation, and in some sections has great natural beauty, so important to a recreation-minded populace. Population of the basin was some 19 million people in 1960, slightly more than ten percent of the national total. For many years the rate of growth has been substantially less than for the country as a whole, and this trend is expected to continue. Two cities had more than one-half million people - Pittsburgh with 604,332 and Cincinnati with 502,550. In all, there were ten cities with more than 100,000 population, accounting for a total of 3.3 million people.

The basin labor force numbered approximately 6.9 million persons in 1960, or about 36 percent of the area's total population. This can

be contrasted with the U. S. labor force, which was slightly more than 51 percent of the total population for the country in 1960. As is true generally, composition of the basin labor force has been changing until today employment in so-called service and related categories accounts for more than one-half of the labor force. Employment in mining, agriculture, forestry and fisheries has been declining over the years and is expected to continue. This is true nationally as well. Total personal income of nearly 38 billion dollars for the basin in 1960 was slightly less than ten percent of the almost 400 billion for the country as a whole. On a per capita basis it was nearly $2000 per person in the basin as against $2217 for the nation.

Agriculturally, the Basin is a major contributor to the nation's food supply. Favored by fertile soil and a suitable climate, large areas are extensively farmed, particularly in Illinois, Indiana and Ohio. A wide variety of crops are produced and dairy farming and livestock raising are also engaged in on a large scale. The farm picture is a constantly changing one. Farm population in the nation has steadily declined over the years, both in absolute numbers and in percent of total population. From well over 20 percent in 1940, it decreased to 15 percent in 1950 and slightly under seven percent in 1964. The number of farms and total acreage in farms are also smaller, but the average farm size and average value of sales per farm increased. Farm productivity has increased markedly and the agricultural industry has kept pace with our growing economy through continued elimination of unproductive acreage, reduction of marginal operations, application of modern management and operating techniques, and the widespread use of electrical and non-electrical labor saving devices.

The many and abundant natural resources of the Ohio River Basin have influenced the establishment of a variety of industries which characterize the area. Generally, these require large amounts of low cost electric power. The basin is well known as the principal supplier of the nation's coal requirements. With known reserves of large magnitude and a growing market, not the least of which is the electric power industry, coal mining should continue to be a leading activity in the basin. Mining operations have been mechanized to a high degree, so that while employment nationally has dropped from more than one-half million miners in 1940 to less than 163,000 in 1963, productivity in tons per man-day has increased from slightly more than five to nearly 16 over the same period. In addition to coal, the Basin is a leading supplier of salt, lime and clay and produces substantial amounts of oil and natural gas.

A variety of large industrial complexes are to be found in the basin. These include iron and steel centers at Pittsburgh, Youngstown and Wheeling and aluminum, glass and diversified chemical concentrations in the upper Ohio and Kanawha Basins. Major manufacturing and fabrication centers are widely distributed and include Cincinnati,

Columbus, Indianapolis and Louisville. The rubber industry is centered in the Akron-Barberton area which is partially in the basin proper.

A key factor in the economic and industrial development of the basin is its excellent transportation system, so essential to the movement of raw materials into and within the area and to the delivery of finished goods to near and remote markets. Of great historical and economic significance as transportation arteries are the Ohio River main stem and its principal tributaries. Continuing improvements to navigation have assured the importance of this means of transportation for both raw and finished materials in bulk.

Delineation of Market Area

In its work relating to the assembly and analysis of statistics on power requirements and supply for the electric utility industry, the Federal Power Commission has found it convenient to divide the contiguous United States into 48 Power Supply Areas (PSA's). Basically, a PSA embraces the service territories of those interconnected utility systems which operate with some degree of coordination as an essentially self-sufficient group independent of adjacent systems. Isolated utilities are included in the PSA's containing the systems to which they would most likely be physically connected for operational purposes. Over the years there has been a continuing trend to expanded interconnections among systems and increased coordination of power supply planning and operation, necessitating the treatment of power problems on a broader scale. For this purpose, power supply areas may logically be combined into study areas and the latter into power supply regions.

The power market area selected for the Ohio River Basin study consists of parts of Power Supply Areas 7, 9, 10, 12 and 40 and all of 19. The market was chosen not only for its correspondence with the Basin area, but also from the standpoint of operating relationships of the utilities involved. For example, almost all of the Allegheny River tributary basin was excluded from the market because the systems serving it normally coordinate their operations with utilities outside of the Ohio River Basin in western New York and eastern Pennsylvania. Where a reasonable division of a utility service area was not feasible, the market area boundary in some instances extended beyond, or fell short of the Basin border.

The portion of PSA 7 in the Ohio basin market takes in the southwestern portion of Pennsylvania (including Pittsburgh) and roughly the northern half of West Virginia. PSA 9 in the basin market includes almost all of Ohio except the northeastern corner (Cleveland), the northwestern sector (Toledo), and the southwestern portion (Cincinnati and Dayton). Practically all of PSA 10, which covers the southern part of West Virginia and small parts of Kentucky, Tennessee, and Virginia,

is in the Basin market area. PSA 12 includes all but the northern part of Indiana, the southwest section of Ohio (Cincinnati and Dayton) and a small strip of Kentucky which takes in Louisville. PSA 19 takes in most of Kentucky except the Louisville area, the eastern part of the state, and a section in the western half of the state along the Tennessee border. The portion of PSA 40 included in the basin power market covers the southeast corner of Illinois. Exhibit No. 1 shows the Ohio basin power market area in relation to the Ohio River Basin.

Since the Tennessee Valley Authority has overall responsibility for water resource development in the Tennessee River Basin, this tributary drainage basin has been excluded from the comprehensive survey of the Ohio and is therefore not part of the selected power market area. While the Ohio River basin power market area excludes all but the northeast corner of the Cumberland basin, the latter's potential power resources (both hydro and thermal) are considered available to serve the selected market area as well.

SECTION II

POWER MARKET REQUIREMENTS

Utility Service in Market

Electric service in the market area is provided by 318 utility systems - 36 privately-owned and 282 publicly-owned. In 1963, 31 systems had energy requirements greater than 100 million kilowatt-hours, aggregating 114 billion kilowatt-hours. These principal utilities, constituting only ten percent of the total number, account for 95 percent of the market load. The following table summarizes the number of systems and their energy requirements in 1963:

Electric Utilities Serving Market Area

	1963	
	System (No.)	Energy (Billion Kwh)
Privately Owned		
Major Systems 1/	21	112.3
Minor Systems	15	0.2
Total Private	36	112.5
Publicly Owned		
Major Systems 1/	10	2.2
Minor Systems	272	5.5
Total Public	282	7.7
All Major Systems 1/	31	114.5
All Minor Systems	287	5.7
Grand Total	318	120.2

1/ Systems with requirements of more than 100 million kilowatt-hours annually.

Requirements of publicly-owned systems were nearly eight billion kilowatt-hours in 1963, or 6.4 percent of the total market requirements. Of this amount ten major systems accounted for 2.2 billion kilowatt-hours while 272 minor systems had a total of 5.5 billion kilowatt-hours. Publicly-owned utilities include 190 municipals, 91 co-ops, and one state owned. The majority are located in PSA 9 and 12 in the states of Indiana and Ohio, - 69 in PSA 9 and 135 in PSA 12. Largest of the publicly-owned group is the East Kentucky Rural Electric Co-op. Corp.

in PSA 19. Energy requirements of this system were 700 million kilowatt-hours in 1963. Two municipal utilities had energy requirements exceeding 200 million kilowatt-hours - Richmond, Indiana with 272 million and Anderson, Indiana with 240 million.

Total power requirements of the private ownership sector of the industry were 112.5 billion kilowatt-hours in 1963, or 93.6 percent of the total market energy requirements. Practically all of this was accounted for by 21 major systems, with 15 minor utilities having a total of slightly less than 200 million kilowatt-hours. The nine systems with requirements in excess of 5.5 billion kilowatt-hours had an aggregate load of 84.3 billion kilowatt-hours, about 70 percent of the market requirements. Three systems had requirements of over 11 billion kilowatt-hours in 1963. These were the Ohio Valley Electric Corporation (16.2 billion Kwh), American Electric Power Company's Ohio Division (15.2 billion Kwh), and Appalachian Division (11.4 billion Kwh). Two large systems, Electric Energy Incorporated and Ohio Valley Electric Corporation, were formed by groups of private utilities for the specific purpose of serving AEC loads in the market area.

In delineating the utility market for the Ohio River Basin entire systems were taken where practicable. There were a few exceptions where, mainly for geographical and system operating considerations, only portions of utility service areas were included.

There were 223 publicly-owned utilities in 1963 that obtained all of their power requirements from other systems, mostly privately owned. These purchases of 4.5 billion kilowatt-hours represented 57 percent of the public ownership load. Their future load growth is provided for in the expansion plans of the supplying systems. Of the remaining publicly-owned utilities having generation, 34 produced all of their requirements, while 25 purchased and generated some. Altogether, total purchases by publicly-owned systems of 5.0 billion kilowatt-hours accounted for 64 percent of their overall requirements. The following table summarizes their sources of supply:

Sources of Generation of Publicly-Owned Utilities in Market Area

	No. of Systems	1963 Energy - Million Kwh		
		Purchase	Generate	Total
Purchased All	223	4,463	-	4,463
Generated All	34	-	845	845
Purchased/Generated	25	487	1,986	2,473
Total	282	4,950	2,831	7,781

Of those systems generating their own energy requirements, there were nine with loads of 25 million kilowatt-hours or more in 1963. Largest of these was the Columbus Ohio Municipal with 124 million kilowatt-hours.

Past and Estimated Future Power Requirements

Forecasts of power consumption to 1980 may be made with a reasonable degree of accuracy and to 2020 with less precise, but still acceptable results. In general, the principal tool used in the estimating process is the historical record of past experience. Overall requirements are normally arrived at through an analysis of needs based on a class of service in component areas making up the market. Development of the electric power industry has attained a level of maturity such that the pattern of expanding power requirements is well established, giving consideration to those known and potential factors that would affect it in a given area. For example, the number, location and relative requirements of future load centers are unlikely to change from those presently existing. The Ohio River Basin is noted for its concentration of heavy industry and this dominance is certain to continue. Likewise, the position and value in the regional economy of agricultural activities can be closely approximated. Based on past statistics and knowledge of current population trends, well founded estimates of the population and its distribution in the basin may be established.

In 1963 power requirements of the selected market area amounted to 120.2 billion kilowatt-hours with an associated peak demand of 19.7 million kilowatts as compared with 42.5 billion kilowatt-hours and 7.6 million kilowatts in 1950. It is estimated that this load will increase to 316 billion kilowatt-hours and 53.8 million kilowatts by 1980 and 1.7 trillion kilowatt-hours and 290.7 million kilowatts in the year 2020. Estimates to 1980 were derived by forecasting the needs of the various classes of service making up the overall load in each power supply area and then projecting these totals to the year 2020. Table 1 and Exhibit No. 2 show past and estimated future power requirements of the power market area.

These figures reflect an above average increase between 1950 and 1955 due to completion of the Atomic Energy Commission's gaseous diffusion plants in Chillicothe, Ohio and Paducah, Kentucky (PSA 40). Until 1963, this relatively constant load of about 23 billion kilowatt-hours represented a substantial, but diminishing proportion of total power needs in the area. With a reduction in the production of nuclear materials in 1964, power requirements will be greatly lessened. However, as non-defense applications of atomic energy increase, it is expected that the AEC electric load will regain its former level by 1980.

Load factor in the power market area is relatively high, being currently in the order of 70 percent. This is due to the area's large industrial load and the nearly 100 percent load factor AEC load. As lower load factor uses of electric power expand more rapidly, the overall area load factor is expected to decline somewhat in the future, ranging between 67.1 percent in 1980 and 67.8 in 2020.

Historically, the coincident annual peak demand of the market area has occurred in the winter and it is expected to continue through the period of estimate. The time of maximum demand is primarily determined by the seasonal characteristics and requirements of the utility load and climatological conditions in a given area. It is true, as in other parts of the country, that the growing requirements of summer air conditioning have influenced to a large degree the increase in off-peak monthly maximum demands relative to the annual peak, but not enough to effect a reversal of the seasonal occurrence of annual peak. Also, off-setting air conditioning demands to a considerable extent is the fast growing electric space heating load in the area. The following table shows the variation of 1963 monthly peak demands in percent of annual for the larger systems combined in the market area:

1963 Monthly Peak Demand in Percent of Annual

January	94	July	94
February	92	August	92
March	91	September	91
April	89	October	89
May	89	November	92
June	95	December	100

The diverse nature of the electric utility load and the lengthy east-west dimensions of the market area, which involve a time zone transition, give rise to a diversity condition in which peak demands in different parts of the market may vary in time. Thus, the overall coincident market area peak would be less than the sum of non-coincident peaks of the market components in a given period. The various types of peak diversity are daily, weekly, monthly, and annual. All types represent potential benefits in the form of reduced capacity requirements that can only be realized through system interconnections, adequate in number and capacity to permit the free flow of power. This is generally true of the transmission network serving the area.

Loadwise, PSA 9 is the largest in the market and PSA 19 the smallest. Energy requirements of PSA 9 of nearly 48 billion kilowatt-hours in 1963 represented 40 percent of the area total and is estimated to decline slightly to about 38.5 percent of the market total by 2020. Table 2 shows past and estimated future power requirements of the selected power market area by Power Supply Areas. PSA energy requirements in percent of total market are as follows:

Energy Requirements of Power Market
by
Power Supply Areas

	1963 (Actual)		1980 (Est.)		2020 (Est.)	
PSA	Billion Kwh	% Total	Billion Kwh	% Total	Billion Kwh	% Total
7	16.9	14.0	42.6	13.5	215.5	12.5
9	47.8	39.8	117.8	37.2	664.2	38.5
10	11.5	9.6	31.8	10.1	176.8	10.2
12	30.6	25.5	94.6	29.9	538.0	31.2
19	4.0	3.3	13.2	4.2	70.3	4.1
40	9.4	7.8	16.1	5.1	61.0	3.5
Total	120.2	100.0	316.1	100.0	1,725.8	100.0

The above data indicate in a general way the distribution of load through the market area and also the expected relative growth of the individual power supply areas. PSA 9 and 12 together account for approximately 70 percent of the total requirements. Of the six PSA's involved, PSA 12 is expected to show the greatest growth rate to 2020 with PSA 40 having the lowest compared to the overall rate. The figures for PSA 9 and 40 reflect the effect of the large, constant AEC loads which by 1980 are assumed to have regained their high levels prior to the 1964 cutback.

Load Centers

Utility customers are usually distributed over its service area in varying degree of concentration. This suggests the useful concept of load centers, whose location and power needs are an important consideration in system planning of generating and transmission facilities. They are the key points on the backbone of a transmission network for the reception of large blocks of power and which may also coincide with power

supply centers. Load centers generally conform to concentrations of population such as metropolitan areas, or groups of communities, and heavy power consuming industrial complexes.

The overall energy needs of 36 identifiable load centers in the power market area, having requirements of at least 200 million kilowatt-hours each was approximately 82 billion kilowatt-hours in 1963. This represented 68 percent of the total market requirements. Four load centers - Chillicothe and Cincinnati, Ohio, Joppa, Illinois/Paducah, Kentucky, and Pittsburgh, Pennsylvania - had loads greater than five billion kilowatt-hours, aggregating 36.5 billion. Largest by a wide margin and the only one with requirements exceeding 10 billion kilowatt-hours was the AEC installation near Chillicothe, Ohio with more than 18 billion kilowatt-hours. PSA 9 has the most load centers. Exhibit No. 3 shows the geographical distribution of the 36 centers and lists their 1963 energy requirements.

Classified Sales

The utility load is comprised of the demands of the various customers served. Their differing characteristics and requirements permit their assignment into distinct categories. Such classification is essential to the orderly and efficient management of a utility and facilitates the analysis and utilization of power requirements and supply data. Further, consideration of power needs on a class of service basis, taking into account all the factors peculiar to a particular category, helps to identify the overall picture of an area's industrial and commercial development, the state of its economy, and the probable direction of future growth.

In studies such as this, classes of power use may be broadly defined as rural and residential, commercial, industrial, and all other. Usually of relatively small magnitude powerwise, the last named would include such uses as street lighting, water pumping, schools, other municipal services, etc. Rural consumption includes electric energy used in agriculture and depends on the type of farm and the availability of labor saving devices and the extent to which they are employed. Residential consumption is a function of population, average use per customer and appliance saturation. For the most part, the commercial category encompasses those utility customers serving directly the functional and recreational needs of people in their day-to-day lives. It would include such establishments as retail stores, filling stations, dry cleaners, theatres, shopping centers, etc. The industrial segment of load includes the large power consumer and may cover a wide range of industry types, such as mining, chemical, primary metals, manufacturing, etc. Some systems do not distinguish between commercial and industrial types but characterize them solely on the basis of power requirements. This practice may also apply to some farming operations because of their size.

Tables 3 and 4 show sales by class of service for the total market and by power supply area. The industrial requirements of 70 billion kilowatt-hours accounted for 58.6 percent of the 120 billion kilowatt-hours of total energy requirements in 1963. In five of the six areas comprising the market, industrial sales represent the largest component. Only in PSA 19 were industrial deliveries less than another class of service, rural and residential. The large industrial load in PSA 9 and 40 compared to other classified uses is due to requirements of the AEC gaseous diffusion plants. The AEC needs represented more than 30 percent of the total industrial load in 1963 and are estimated to exceed 13 percent in 1980.

SECTION III

UTILITY POWER SUPPLY FOR MARKET

Generating Facilities

The utility market of the Ohio River Basin was supplied at the end of 1963 by an aggregate generating capacity of some 25 million kilowatts. Ninety-six percent of this total was located in the Basin and the remainder in adjacent areas. Table 5 shows the distribution of this supply by PSA's and by type of prime mover. Steam-electric capacity predominates with slightly more than 98 percent of the total utility power supply. A number of factors have influenced this pattern of development to the present time. Prominent among these are: abundant, low cost sources of coal; adequate and suitable supplies of condensing water; the limited number of economically and engineeringly feasible conventional hydroelectric sites; and establishment of heavy power consuming industrial loads in relative proximity to power supply centers.

As stated previously, 318 systems provide electric utility service in the market area. Included in this number are 31 systems, each with annual energy requirements in excess of 100 million kilowatt-hours. Table 6 lists these systems and shows their respective energy requirements and installed generating capacities in 1963. As a group, the 31 principal systems owned and operated nearly 98 percent of the total power supply serving the market. The other systems operate a relatively small amount of generating facilities and obtain most of their requirements from the larger utilities.

Transmission Facilities

More than 27,500 circuit miles of transmission of 69 kilovolts and above serve the selected utility market in the Ohio River Basin, effectively linking together sources of supply with load centers and interconnecting systems both in and out of the market. Principal voltage levels are 345 Kv, 138 Kv, and 69 Kv with circuit mileages in the order of 2,500 and 15,000 and 10,000 miles, respectively. Supplementing this is an extensive sub-transmission system whose main component is a 34.5-kilovolt network in excess of 7,500 circuit miles. Exhibit No. 4 shows the location of principal electric facilities.

The 345-kilovolt backbone consists mainly of facilities of the American Electric Power (AEP), Ohio Edison, and Ohio Valley Electric Corporation systems. The network extends from Roanoke, Virginia to the northwest corner of Indiana, a straight line distance of approximately 500 miles. One large loop stretches across Ohio into Indiana. The single circuit northern leg runs from AEP's Muskingum River steam plant

in eastern Ohio northwesterly to Lima, Ohio and Fort Wayne, Indiana. The western leg from Fort Wayne to the Tanners Creek steam station near the point where Indiana, Kentucky and Ohio meet, is double circuited with a sub-loop serving Indianapolis. The eastern segment, also a double circuit, links the Sporn and Muskingum River plants. The southern leg consists of OVEC's four circuits between its Clifty Creek and Kyger Creek steam plants. Tanners Creek and Sporn plants interconnect with the OVEC network. Off this loop, lines radiate from Sporn to Kanawha River plant and Roanoke; from Muskingum River to Kammer and Tidd plants, Canton and Cleveland; and from Fort Wayne to South Bend and Chicago. A double circuit line delivers the output from AEP's Breed steam plant south of Terre Haute, Indiana to South Bend. A connection is made off this line to Illinois Power Company. Ohio Edison's 345-kilovolt system at the present time serves to deliver power from its W. H. Sammis plant on the Ohio River to Star Substation, west of Barberton. Nearly 130 miles of Ohio Edison line, designed for 345 kilovolts are currently operating at 138 kilovolts.

Besides the 345-kilovolt EHV out-of-market ties with Chicago and Cleveland, there are numerous lower voltage connections with other markets. There are many ties with TVA at 161 kilovolts, 138 kilovolts and 69 kilovolts, mostly through AEP's Appalachian Division, Kentucky Utilities Company, and Louisville Gas and Electric Company. Output from TVA's three major steam plants in the Basin is fed into that system's extensive 161-kilovolt network. The Basin market is also interconnected to the East with the Pennsylvania-New Jersey-Maryland Interconnection (PJM) at 230 and 115 kilovolts and the Carolinas' Virginia Power Pool (CARVA) at 138 kilovolts. To the West, the Basin market has ties with the Illinois-Missouri Pool (which takes in the Union Electric Company of St. Louis) at 230 kilovolts, 161 kilovolts and 138 kilovolts through Illinois Power Company and Central Illinois Public Service Company which are partially included in the Basin.

In addition to the continuing expansion of transmission facilities within the Basin, such as the AEP - Duquesne Light 345-kilovolt tie, the establishment of a 345-kilovolt interconnection by the Cincinnati, Columbus and Dayton systems, and the AEP - Allegheny Power 500-kilovolt tie, further EHV links with neighboring areas are proposed by the utilities as they more closely coordinate system planning and operations. Additional 345-kilovolt interconnections are planned with Cleveland and a 500-kilovolt link with PJM Interconnection is part of the Fort Martin-Keystone mine-mouth projects now under construction. A similar tie between AEP and Virginia Electric and Power Company of the CARVA pool is in the construction stage. Future EHV developments in the Basin must built on the existing system as a nucleus. The National Power Survey suggests a possible pattern of transmission for 1980 whose principal feature would be a large 700-kilovolt loop approximating the Basin boundaries. This represents a doubling of the current EHV

level. Such doubling is fairly common practice in the industry, and considered to be the minimum increase in transmission voltage advance on a growing system from an engineering and economic standpoint.

Utilities in the Basin and those comprising the market are part of the so-called Interconnected Systems Group (ISG), which extends from Florida to the Canadian border in Montana. Although ISG operates in parallel, the degree of integration and coordination among systems and among sub-groups of systems varies and is not complete, but is increasing in degree of achievement. There are many short and long term agreements in effect in ISG providing for the scheduling of reserve, firm and emergency power transfers, economy flow energy, and maintenance. This permits the planning and sharing of new capacity and the utilization of larger units. Basic to this concept of full coordination of planning and operations is a transmission system with sufficient capacity and facilities to allow the free flow of power in amounts required with reliability and economy.

Future Capacity Requirements for Market

While power requirements for the immediate future can be estimated with a reasonable degree of accuracy, it is more difficult to develop a power supply program to meet the needs of the distant future. Since the time required for construction is considerable, the planning of new facilities in advance of actual need is a vital continuing process. Most utilities have already settled on the timing, sizing and location of new sources of supply to meet their 1970 load and have begun, or announced, the start of this construction. Table 7 shows all capacity additions scheduled for completion in the next several years by the utilities serving the selected market. In a more preliminary fashion the probable composition of the 1970-80 power supply is also known. Any attempt in identifying details of new capacity beyond 1980 would be of questionable value at this time in light of continuing progress in the art of power generation and transmission and the influence of other factors which bear on the situation. Examples of industry changes referred to are the trend to: large unit sizes; extra high voltage transmission levels; increased interconnection and coordination among systems; competitive position of nuclear power relative to fossil fuel; steam-electric capacity; and of capacity designed for specific portions of utility loads.

Generating capacity in the Ohio River Basin is predominantly thermal electric. A prime consideration heretofore in the location of steam capacity was an adequate and suitable supply of condensing water. However, with advances in cooling tower technology, this is no longer a limiting factor. In considering the installation of a conventional steam unit, cost of generating near the fuel supply and

transmitting power to load must be weighed against the cost of transporting fuel and generating close to the load. On the other hand with nuclear generation and the absence of fuel transport problems, greater freedom of choice with respect to location is possible. With increasing competition for land for other purposes, the acquisition of property for utility use becomes more costly and difficult. As system ties and coordination increase, the changing requirements of capacity planning introduce further complications. In the face of a growing concern over air pollution, the contribution of fuel-electric plants to this undesirable condition must be given serious thought in system planning. The same is true with limitations governing allowable temperature rise in water sources furnishing condensing water for thermal plants.

The foregoing demonstrates the variety of factors which must be considered in planning the expansion of an area's power supply. It emphasizes the uncertainty attached to the precise formulation of a long range program of capacity additions which the industry's past experience indicates would be subject to modification prior to implementation.

In addition to actual customer demands that have to be continually met, capacity is also necessary for reserve purposes. The sum of the two constitutes total required capacity. In general, if suitable standards of adequacy and reliability of service are to be maintained, reserves must be provided for: scheduled maintenance of equipment; unscheduled equipment outages; and errors in load forecasting. The question of proper reserves is a complex and difficult one. Normally, as the interconnection and coordination of systems increase, reserve requirements on a peak percentage basis would tend to decline. Offsetting this factor, however, is the increased vulnerability to interruption to service which accompanies growth in magnitude and complexity of system operations and in the use of unit sizes with ever higher steam pressures and temperatures. While a great deal of progress has been made in the application of probability methods and computer techniques to the reserve problem, its determination is still based, to a large extent in the industry, on judgment and experience. Acceptable reserves in percent of peak are generally of the order of 12 to 16 percent, although actual capacity margins in recent years have been substantially higher for some parts of the country, including the Ohio River Basin. In December 1963, for example, excess dependable capacity margins (including net firm purchases) as a percentage of the annual peak were of the order of 28 percent nationally and 21 percent for the Basin. Because of this and to correlate capacity additions under construction or definitely scheduled by systems in the Basin and assumed retirement of old thermal units with estimated peak demands, reserves are taken at 17 percent for 1970, declining to 14 percent by 1980. This assumes full integration and coordination of system planning and operations by the latter year. Table 8 shows total capacity needs for the selected market in 1970 and 1980.

The difference between estimated total requirements in 1970 and 1980 and known available dependable capacity for those years determines the magnitude of the additional power supply needed. Not all of the capacity existing in 1963 will still be in service through the study period. As thermal units reach the end of their useful lives, they are retired. For study purposes this is taken at approximately 35 years. Based on this, 2180 megawatts of thermal capacity would be retired from 1964 to 1970 and 4,480 megawatts by 1980. Because of the durable nature of project construction and simplicity of operation, hydroelectric units ordinarily have a much longer service life than thermal capacity and are not normally retired in power studies.

Utilities in the Ohio River Basin have a long history of power transactions, both firm and non-firm, with interconnected systems in other areas. This practice will continue to grow as inter-area ties increase in number and capacity. While both firm imports and exports of power are assumed in the future, exports are estimated to be much larger in magnitude, mainly because the low fuel cost advantage favors the location of large blocks of steam capacity in the Basin. Firm imports are estimated at 2,000 megawatts in 1970 and 3,000 in 1980, compared with exports of 5,000 and 11,000 megawatts, respectively.

On the basis of the foregoing, the additional dependable capacity required to serve the load of the selected market area is estimated at 6,570 megawatts in 1970 and 42,520 in 1980. All of the additional needed for 1970 is assumed to be located in the Basin, while for 1980 all but 3,000 megawatts would be similarly located. Table 9 shows the distribution by tributary basins of the estimated 1970 and 1980 dependable capacities required for the selected market.

SECTION IV

ELECTRIC GENERATING FACILITIES IN THE OHIO RIVER BASIN

General

Utility and non-utility owned generating capacity in the Ohio River Basin amounted to 31.7 million kilowatts in 201 principal plants (5,000 kilowatts and over) at the close of 1963. By type of prime mover, the basin power supply is preponderantly steam-electric, there being only 1.1 million kilowatts in hydroelectric stations and 89.6 thousand kilowatts (less than 0.3 percent) of internal combustion capacity. The utility segment was nearly 12 times the non-utility capacity. The following table shows the distribution of the utility and non-utility generating capacity in 1963 by type of prime mover:

Ohio River Basin

1963 Principal Generating Stations
(5 Megawatts and Over)

Prime Mover		Ownership Utility	Ownership Non-Utility	Total
Hydro -	Installed Mw	1,001.1	102.0	1,103.1
	No. of Plants	19	1	20
Steam -	Installed Mw	28,073.0	2,392.0	30,465.0
	No. of Plants	109	60	169
I.C. -	Installed Mw	82.8	6.8	89.6
	No. of Plants	11	1	12
Total -	Installed Mw	29,156.9	2,500.8	31,657.7
	No. of Plants	139	62	201

The utility owned power supply includes not only capacity available for the selected utility market area, but capacity for markets outside the Basin. Of the total utility supply of 29,157 megawatts shown in the above table, some 5,100 megawatts serve loads outside the Basin. Included in the latter group are three TVA steam plants, with over one thousand megawatts capacity each.

Table 10 and Exhibit No. 5 show the location and type of each utility and non-utility power station of 5,000 kilowatts and over in the Ohio River Basin.

Utility Generating Facilities

Steam Electric Capacity - In 1963, utility owned steam-electric capacity in the Ohio River Basin amounted to 28,080 megawatts. Of this total, 23,611 megawatts were operated to serve the selected market area and 4,469 megawatts served markets outside the basin. There is wide variation in the makeup of the steam-electric supply with regard to such characteristics as plant size, unit size, age, steam conditions, thermal efficiency, etc. There were more than one hundred plants ranging in size from 1,500 megawatts down to less than five. Seven plants, exceeding 1,000 megawatts in size, accounted for some 8,500 megawatts, or 30 percent of the total steam capacity. The two largest stations were TVA's Shawnee and Paradise, 1,500 and 1,408 megawatts, respectively.

Distribution of 1963 Steam-Electric Supply by Plant Size

Size of Plant (Mw)	No. of Plants	Capacity in Range (Mw)	Capacity in Range (%)
Over 1,000.0	7	8,509	30.3
500.0 - 999.9	10	6,248	22.3
250.0 - 499.9	25	8,687	30.9
100.0 - 249.9	17	3,123	11.1
50.0 - 99.9	12	755	2.7
25.0 - 49.9	12	450	1.6
Under 25.0	28	308	1.1
Total	111	28,080	100.0

More than half of the total capacity is accounted for in 17 plants of 500 megawatts and over, while the aggregate capacity of 40 plants under 50 megawatts is less than three percent of the total. Power Supply Areas 9 and 12 consisting of Indiana and Ohio (except the Cleveland and Toledo areas in Ohio and the northern part of Indiana) account for more than 55 percent of steam capacity in the basin.

There are two nuclear power units in the Ohio River Basin. The pioneer Shippingport unit on the Duquesne Light Company system was placed in service in 1958. It is now rated at 100 megawatts.

Operating experience gained with this pressurized water unit has proved its value as an experimental project and has advanced immeasurably nuclear reactor technology as applied to the art of electric power generation. A 12.5 megawatt organic cooled and moderated unit on the municipal system of Piqua, Ohio, went critical in June 1963 and was scheduled for commercial service in 1964.

Economics of Steam Electric Capacity - The Ohio River Basin is noted for its large deposits of coal. For the most part, this fuel is widely, though somewhat unevenly, distributed through the basin and with the exception of few areas, is easily and economically mined. Except for the use of some gas and oil for start-up purposes, coal is burned exclusively for steam-electric generation. In 1963, total consumption by utilities exceeded 60 million tons at a cost of more than 270 million dollars. These requirements represent nearly 29 percent of the coal burned nationally by the utility industry and 19 percent of all fuel consumed as expressed in terms of coal equivalent. Average cost per ton burned in the Basin was approximately $4.50. By tributary basins it ranged from a high of about $7.00 in the vicinity of Columbus, Ohio (Scioto River basin) and over $6.00 in the Dayton, Ohio area (Miami-Little Miami basin) to a low of less than $4.00 in the Green River Basin (Western Kentucky) and the Muskingum River basin (Eastern Ohio). There were only four tributary drainage basins where the average cost of coal as burned exceeded $5.00 per ton. Related to heat content of the coal, average cost for the Basin was 19.2 cents per million Btu's as against 25.0 cents for the United States. Exhibit No. 6 shows geographically the weighted cost of coal as burned for selected groups of plants in the basin in 1963. Average net heat rate for the basin's steam-electric supply was approximately 10,120 Btu's per kilowatt-hour compared to nearly 10,500 nationally. Fuel cost per net kilowatt-hour produced was 1.95 mills for the basin as against 2.66 for all fuels in the United States. Utilization of steam-electric capacity as measured by average annual plant factor was greater for the basin than the country. In 1963, it was 51 percent nationally and over 62 percent for the basin. From the foregoing, it is seen that the thermal efficiency of the Basin's steam power supply was higher than the national average, while unit fuel costs were substantially lower.

Many of the nation's most efficient and low fuel cost generating stations are located in the area. There were 11 plants with 1963 heat rates under 9,400 Btu's per kilowatt-hour, led by two American Electric Power System stations with heat rates less than 8,900. Although TVA's new Paradise station on the Green River is omitted from the foregoing statistics because of limited operating experience in 1963, it had the lowest fuel cost of any plant in the Basin, less than 13 cents per million Btu's. Next lowest was Allegheny Power System's Albright plant in the Monongahela Basin in West Virginia with 14 cents. In all, there were nine plants in 1963 with coal costs of 17 cents per million Btu's, and under.

The concept of mine-mouth generation has been developed to a high degree in this area. The practice of locating large aggregates of generating capacity in or near major coal fields has the effect of minimizing transportation costs associated with the movement of fuel to its point of use. A large proportion of the basin's steam capacity falls in this category. In addition, much of it has the added advantage of having sizable industrial loads nearby. That the industry recognizes the economic merit of mine-mouth locations in system planning is evidenced by the continuing expansion of regional power supplies in this direction. With recent advances achieved in the design of cooling towers, greater freedom and flexibility in siting new capacity are possible, subject only to the usual economic and other planning criteria.

It is generally agreed that coal reserves of the United States, including the Ohio River Basin, are more than ample to meet the growing requirements of the electric utility industry well into the foreseeable future. For example, according to the Federal Power Commission's National Power Survey, total recoverable coal reserves in the United States (excluding Alaska) as of January 1, 1960 were 830 billion tons on the basis of only 50 percent recovery. By comparison, the coal equivalent of total fuel requirements for estimated thermal generation in 1980 is 900 million tons. Of this amount, coal-fired generating plants are expected to require 500 million tons. Thus, from this standpoint, conventional, coal-fired steam plants can be expected to continue to play a major role in the basin's power supply.

Coal production costs vary widely with geologic conditions, mining methods, quality control practice and other factors. Mining is now a highly mechanized industry. This continuing mechanization has brought about greatly increased productivity as measured in tons per man-day. In the 1952-62 decade, average productivity slightly more than doubled from 7.5 tons to 15.4 tons per man-day. While future prices at the mine will reflect changes in mining conditions and techniques, wage structures, and relative costs of competing fuels, the outlook, according to the National Power Survey, is for stable to moderate reductions in the F.O.B. mine costs.

<u>Internal Combustion Capacity</u> - Internal combustion capacity in the Ohio River Basin is insignificant in the overall electric power supply, amounting to only 130 megawatts, or less than one-half of one percent of the total capacity in 1963. Out of a total of 31 plants in the Basin, there were but 11 installations of five megawatts, or greater, aggregating 83 megawatts. Largest was the 11.3-megawatt plant in the Hamilton, Ohio, municipal system. All of the internal combustion capacity in the Basin serves the selected market area. In addition, there were three other stations totalling 14.4 megawatts located in the market area, but not in the Basin. Generally, the supply is made up of small, municipally-owned units, many of them less than 500 kilowatts in size.

While the role of internal combustion and gas turbine units in the Basin's power supply has been of minor importance in the past, technological advances in recent years (principally the successful application of aircraft type jet engine gas turbines to electric power generation on a large scale) have justified their economic and operational consideration in system planning for reserve and peaking purposes and as sources of emergency auxiliary power. Indicative of this progress, is the planned addition subsequent to 1963 of 183 megawatts of gas turbine capacity at five locations in the Basin. Outstanding in this construction program is the 108-megawatt jet engine unit on the Cincinnati Gas & Electric System.

Hydroelectric Capacity - In 1963 conventional hydroelectric power in the Basin amounted to 1,002 megawatts in 20 plants. This represented less than four percent of the total utility owned power supply. The stations range in size from 270,000 kilowatts to 800 kilowatts. There is only one existing project on the main stem of the Ohio River, namely, the 80.3-megawatt installation at the Ohio Falls navigation dam at Louisville, Kentucky. The three largest plants (each 100 megawatts or more) account for slightly more than one-half of the total hydro. The Cumberland River Basin, has the largest amount of developed hydro, with a total of 627 megawatts, followed by the Kanawha-Little Kanawha Basin with a total of 149 megawatts. The following table shows the 1963 utility hydro capacity by tributary drainage basins.

1963 Hydroelectric Capacity in Ohio River Basin 1/

Tributary Basin	No. of Plants	Installed Capacity (Mw)
Cumberland	6	626.9
Kanawha-Little Kanawha	7	148.7
Lower Ohio	1	80.3
Monongahela	2	70.4
Allegheny	1	28.8
Licking-Kentucky	1	28.3
Wabash	2	17.7
Total	20	1,001.1

1/ Excluding Tennessee River Basin.

Less than 33 percent of the Basin hydro capacity serves the selected market area. Most of the power, including all of the Cumberland basin capacity, is utilized on the load of TVA. Two Pennsylvania Electric Company generating stations - Piney (28.8 Mw) in the Allegheny Basin and Deep Creek (19.2 Mw) in the Monongahela Basin are part of the PJM power supply.

There were 400 megawatts in hydroelectric power projects under construction at five locations in the Ohio Basin at the close of 1963. Only two of these projects, however, would serve the Basin market. These are the 81-megawatt installation at Markland navigation dam on the main stem below Lawrenceburg, Indiana, and the 61-megawatt Laurel project in the Cumberland Basin. The 258 megawatts at the remaining three sites, also in the Cumberland Basin will probably be marketed through the TVA system.

Non-Utility Generating Capacity

Non-utility owned capacity in the Ohio River Basin is relatively small in magnitude. Generally, these plants are not large in size and very often the generation of electric energy is complementary to some other function in the industrial process, as for example, the utilization of by-product fuels or the production of process steam. It is difficult to assess the future role of this capacity in the absence of detailed information such as plant capability, unit size, age, steam conditions, capital and annual costs, operating characteristics with reference to manufacturing or process requirements, etc. For study purposes, any large scale expansion of non-utility power supply is considered unlikely beyond 1970 and existing installations are taken to remain unchanged, although some capacity retirements may be expected.

In 1963, there were 62 non-utility power plants of 5,000 kilowatts and over in the Ohio River Basin, with an aggregate installed capacity of 2.5 million kilowatts. More than half of the non-utility power supply is accounted for in the steel and chemical industries, generally in the eastern part of the Basin.

Except for Union Carbide Carbon Company's 102-megawatt hydroelectric station at Alloy, West Virginia and one gas turbine plant of 6.8 megawatts, all of the non-utility owned power supply is steam-electric. Sixteen plants or 27 percent of the total number account for 71 percent of the total steam capacity. Largest among them is the 450-megawatt non-utility portion of the Kammer steam plant at Captina, West Virginia, jointly owned by Ormet Generating Corporation and Ohio Power Company. Two additions to the Basin's non-utility generating capacity were placed in service in 1965 - a 125-megawatt unit by the Aluminum Company of America at its Warrick plant in southern Indiana and a 20-megawatt unit by United States Steel Company at its plant in Clairton, Pennsylvania.

SECTION V

FUTURE ELECTRIC UTILITY CAPACITY IN THE OHIO RIVER BASIN

Having established estimates of the future power load of the selected market area and additional capacity requirements needed to serve it, it only remains to specify in a broad manner the makeup of this augmented power supply. Certain general, but valid observations may be made concerning generating capacity to be installed in the coming years. The largest proportion of new generation will continue to be conventional, coal-fired steam units located in the coal fields of the Basin. Also, in view of progress being made in reduction of coal delivery costs through such innovations as unit trains, improved and more effective utilization of transportation equipment, and better coordination of scheduling from loading at the mine to unloading at the plant, it is reasonable to look for increases in conventional steam capacity near load centers. With units of one million kilowatts available today, sizes of 1.5 million may be expected by 1980 and even larger unit sizes in the more distant future, when plant capacities may be as large as five million kilowatts. Expanded use of cooling towers can be expected and condensing water requirements as obtained from natural sources will be less restrictive than heretofore in the siting and sizing of new generating stations. Among the most critical factors governing site selection and plant design will be air pollution restrictions on fuel electric generation and thermal pollution in densely populated and industrialized areas.

Some increase in nuclear capacity is assumed for the market by 1980, mostly in the peripheral areas where fuel costs are not as low as at mine mouth and where local load protection is desirable from the standpoint of system reliability. It is beyond 1980, however, that the relative economics of conventional and nuclear steam capacity will probably change and nuclear power may be expected to register its greatest gain. The National Power Survey estimates the capital cost differential in favor of conventional steam capacity will very likely have narrowed to $12 per kilowatt, or less, by 1980. Expressed in terms of fossil fuel prices, the so-called "break-even" costs in 1980, above which nuclear units could be expected to be more economical, would vary from 12 to 19 cents per million Btu's as compared to over 30 cents in 1967. Since completion of the National Power Survey these cost differentials have been substantially reduced. In addition to the growing importance of nuclear power, other developments in the art of generation are certain to evolve that will affect the future power supply picture.

Capacity must be available to serve all portions of the system load curve from base to peak. In the past, before loads had reached their present levels of magnitude, utilities usually depended on their

older, less efficient thermal units and hydro capacity, to serve the upper, or peak portions of the load. As new capacity was placed in service on the base of the load, existing units moved progressively upwards. With utility loads approximately doubling every ten years and with the rapid growth in power pooling, requirements are reaching an order of magnitude where old units available for peaking and reserve duty may not be sufficient for this purpose and capacity will have to be provided specifically for such functions. Optimum utilization of large steam units discussed above requires their operation at relatively high load factors over their lifetime, perhaps in the order of 65 percent. This would correspond to an average annual use of some 5,700 hours per year. System planners must resort to other prime mover types for peaking and reserve functions that would operate only a limited number of hours per year, say up to 1,500 and 2,000. To economically justify the high production expenses usually associated with such restricted operation, peaking and reserve capacity should have low investment costs relative to base load generation. Capacity is available today for such specialized duty in unit sizes commensurate with system loads. Examples are conventional and aircraft jet engine type gas turbines, peaking steam, and pumped-storage hydro power. It is believed that systems serving the market will take advantage of all these, particularly jet engine installations, such as the Cincinnati unit, and pumped-storage opportunities and that the future will witness a large scale expansion of these types of peaking power supply. The availability of low cost pumping energy in the Basin enhances the attractiveness of pumped storage as a source of economical peaking power, while potential conventional hydro projects will continue to be developed when economically justified.

The foregoing discussion has presented in general qualitative terms the overall future power supply picture for the selected market area. To attempt to identify in detail this capacity as to size, type, and location would be difficult, and more important, of limited value. As pointed out early in this Appendix, power supply planning is a continuing process in which commitments and decisions are made well in advance of actual need. A power supply program to satisfy 1970 requirements is for the most part finalized by this time and that for the next decade in process of preparation in a preliminary way, subject to changes in any of the factors that enter into system planning. Based on the additions to capacity definitely scheduled and those being considered for future installation, knowledge of the market area with respect to the current level of development in the utility industry, and probable direction of future progress, an allocation of new capacity has been estimated by tributary drainage basins. Table 11 presents the estimated distribution of total utility generating capacity in the Ohio River Basin by tributary basins and prime mover types for 1970 and 1980. Capacity given in Table 11 consists of expected new generation and dependable capacity existing in 1963,

less assumed retirements to the years shown. It includes not only capacity for the Basin's market, but for other markets as well.

The installation of approximately six million kilowatts of new mine-mouth capacity by systems not in the market to serve markets outside the Basin is planned for service soon after 1970. Utilities in the PJM interconnection and a New York system are planning to construct three plants in the Allegheny Basin totalling some 4.8 million kilowatts. These projects will serve markets to the east and north of the Basin. Unit sizes in two of the stations will be 900 megawatts and over 600 in the third. TVA plans to install a 1.15 million kilowatt unit in its new Paradise plant in the Green River Basin. This will raise total plant capacity to 2.5 million kilowatts in three units. In addition to the new steam capacity earmarked for other markets, The Cleveland Electric Illuminating Company and Pennsylvania Electric Company have received a license from the Federal Power Commission to jointly construct the 325-megawatt Kinzua (Seneca) pumped storage project on the Allegheny River in northwestern Pennsylvania. All told, over 17 million kilowatts of basin capacity will serve other markets in 1980, including 11 million kilowatts of firm exports by systems comprising the market.

Fuel-electric supply in the Basin is estimated at nearly 75 million kilowatts in 1980, and hydro over three million. The Upper Ohio main stem will have the largest amount of thermal capacity with almost 21 million kilowatts. The total main stem accounts for over 38 million kilowatts, or more than one half of the Basin total.

In addition to the Kinzua (Seneca) project, the 1980 hydro capacity includes the 380-megawatt Rowlesburg (Monongahela Basin) and 980-megawatt Blue Ridge (Kanawha Basin) pumped storage developments. Both would supply the selected market. The latter is an alternate to the potential Moores Ferry project. Allegheny Power System has received a preliminary permit from the Federal Power Commission for Rowlesburg and American Electric Power System has applied for a license to build Blue Ridge. Columbus & Southern Ohio Electric Company holds a preliminary permit for the Gallipolis navigation project and is considering an installation of 40 megawatts. Several other potential installations at navigation dams on the Ohio River are also being given preliminary consideration as possible economic sources of power supply by utilities and others.

By comparison with current levels of power supply and requirements in the Basin, the order of magnitude expected in 2020 is extremely large. Energy needs of the selected market are estimated at some 1.7 trillion kilowatt-hours, while the peak demand is expected to be about 290 million kilowatts. Total capacity requirements may well range upwards of 400 million kilowatts in the Basin. This would include

capacity for the market peak, reserves, and capacity for other markets in the form of exports out of the Basin market and capacity installed by systems not in the selected market. Without the knowledge of developments that could revolutionize the art of generation, the composition of this tremendous power supply can only be speculative in nature. With this in mind it can be considered that: one-half of the total, or 200 million kilowatts would be coal-fired steam capacity located mostly in the coal regions, but with some capacity near load centers; 30 percent, or 120 million kilowatts, in nuclear steam power would be feasible; ten percent, or 40 million kilowatts of hydro capacity, largely pumped storage, would be used for peaking and reserve needs; and the remaining 40 million kilowatts of peaking and stand-by power would consist of gas turbine and old steam units. The sole purpose of this allocation is to present in rough dimensions the electric power supply system that may be realized in 2020 and that will have to be considered by those charged with the responsibility of planning and administering the optimum utilization of the water and related land resources of the Ohio River Basin.

SECTION VI

UNDEVELOPED HYDROELECTRIC POWER IN THE OHIO RIVER BASIN

General

In the Ohio River Basin, exclusive of the Tennessee River Basin, relatively little use has been made of available hydroelectric power resources for supplying the electric power demands of the area. At the end of 1963 twenty utility hydroelectric stations in the area had a combined generating capacity of approximately one million kilowatts, or 3.4 percent of the area's total utility power supply. Several new hydro projects are scheduled for construction in the near future and other developments are in the study or planning stage for construction in later years.

Table 11 shows the existing and planned future hydroelectric capacity on the main stem and the several tributaries of the Ohio River in 1963, 1970 and 1980. In the latter year, utility hydro capacity will amount to an estimated 3.25 million kilowatts, or 4.2 percent of the utility total supply. One-half of the hydro capacity or 1.6 million kilowatts will be in pumped storage projects for which license applications have been filed with the Federal Power Commission. The remainder is in conventional hydro plants. In the distant future, many of the area's potential hydroelectric power resources will be developed as conventional projects to supply the peaking portion of the electric load. In addition, the low cost fuel resources, favorable topography and expanding power requirements of the area will stimulate the construction of many large capacity pumped storage power plants to serve the same purpose.

Undeveloped Hydroelectric Resources

The Federal Power Commission in cooperation with other Federal agencies compiles and publishes basic data on undeveloped hydroelectric power resources throughout the United States. The estimates of undeveloped water power include projects fully examined as to their physical and economic feasibility as well as projects at sites where physical conditions indicate engineering feasibility and promise of economic feasibility at some future time. The estimates are subject to revision and change as additional information on costs of projects and alternatives become available.

As of the end of 1963 the estimated undeveloped conventional hydroelectric power resources of the area amounted to almost 4.8 million kilowatts of installed capacity with an average annual output of about 15.0 billion kilowatt-hours. Table 12 lists 69 sites for possible conventional hydroelectric power development on the main stem and the

tributaries of the Ohio River, exclusive of the Tennessee. On the main stem, power potentials are related to Federal navigation improvements with dams higher than at present with more favorable head and flow conditions for power generation. On the tributaries hydroelectric installations are generally related to the construction of multiple-purpose reservoirs.

The distribution of the undeveloped conventional hydroelectric power resources among the principal tributaries and portions of the main stem of the Ohio River are as follows:

Undeveloped Conventional Hydroelectric Power in the Ohio River and Tributary Basins

	Installed Capacity (Megawatts)	Average Annual Output (1,000 Mwh)
Allegheny	240	355
Monongahela	697	1,431
Beaver	100	140
Upper Ohio	336	1,767
Kanawha	1,200	4,985
Miami	15	47
Lower Ohio	561	2,830
Licking-Kentucky-Salt	181	518
White	85	370
Wabash	160	410
Green	102	284
Cumberland	1,095	2,051
Total	4,772	15,188

Compared with thermal stations hydroelectric power projects offer many important advantages. Principal among them are: no contribution to air pollution; low operation and maintenance costs; adaptability to remote control and automatic operation; spinning

reserve; long life and correspondingly low depreciation charges; high reliability and low rates of either forced or scheduled outages. Hydroelectric power developments also offer numerous associated benefits such as the potentials for recreation, water supply, and flood retardation. These favorable characteristics provide strong incentives for utilizing the potential hydroelectric resources which can be economically developed. Therefore, reexamination and studies for the purpose of their development are carried out at frequent intervals by public and private interests.

Most non-Federal projects proposed for construction must be licensed by the Federal Power Commission in accordance with the terms of the Federal Power Act. An important conservation requirement of the Act is that the project be best adapted to a comprehensive basin plan for all useful purposes and that the licensee comply with all rules prescribed for the protection of life, health, and property and to insure that the interests of flood control, navigation, recreation and other public purposes are not negated.

Pumped Storage Developments

A pumped storage power plant produces electric energy by using water that has been pumped into a headwater reservoir during off-peak periods. The project then generates power during peak periods of the electric load. This type of power station has come into general use in recent years with the development of the reversible pump-turbine unit. The plants have many of the favorable characteristics common to conventional hydro stations.

Essential to the construction of a pumped storage project is the availability of pumping energy at low incremental costs. This condition is readily found at the present time as the result of significant gains in combustion efficiency, lower fuel costs, increased size of generating units, and more numerous interconnections and power pooling among utility systems. For most pumped storage plants pumping energy requirements are approximately 50 percent greater than the energy generated by them. To be economically feasible such projects are developed at sites having relatively high heads. Other factors of importance are costs of land, length of waterways, appurtenant equipment and associated transmission facilities. Economically attractive projects cost \$100 to \$120 per kilowatt or less.

Pumped storage projects can be combined in some cases with conventional hydro plants and increase materially the installed capacity of the overall development. This enables the use of small stream flows and smaller reservoir capacities to provide a large output for peak load use. Pure pumped storage projects recirculate the same water between a lower and high reservoir. They may be built

at a greater variety of sites and utilize higher heads than are normally available at sites of known potential water power resources.

Little information is available on the location and capacity of potential pumped storage developments in the area. Comprehensive surveys of such potentialities have not been carried out. Until this is done, information on this subject for the Ohio River Basin is limited to the following several projects.

Potential Pumped-Storage Projects

Project	River	Installed Capacity (Kw)	Head (feet)
Kinzua (Seneca) 1/	Allegheny	325,000	798
Rowlesburg 2/	Cheat	380,000	938
Upper Dam (Blue Ridge) 3/	New	900,000	190
Brookville 4/	E.Fk. Whitewater	240,000	NA
Booneville	S.Fk. Kentucky	400,000	560
Cave Run	Licking River, Ky.	350,000	327
Jellies Creek	Jellies Creek, Ky.	135,000	195

1/ FPC L.P. No. 2280 (under construction).
2/ FPC Preliminary Permit - Project No. 2477.
3/ License application filed with FPC - Project No. 2317.
4/ FPC Project No. 2359.

Valuation of Hydroelectric Power

The economic evaluation of a hydroelectric project consists mainly of a comparison of the annual cost and annual value of its power output. Annual cost includes fixed charges on investment, production expenses and administration and general expenses. Annual value is measured by the cost of an equivalent supply of power from an alternative and equally dependable source. The value of hydroelectric power is usually expressed in terms of two components: (1) a capacity value in dollars per kilowatt of dependable capacity; and (2) an energy value in mills per kilowatt-hour applicable to the average annual output of the project.

The annual cost of power from an alternative source becomes equivalent to the value of power from the proposed hydroelectric project only after it has been appropriately adjusted for any and all inherent differences between the two sources of power, their relative distances from the load to be served as measured by required transmission, hydro-steam capacity value adjustments, hydro-steam energy value adjustments and other applicable factors.

The investment in hydroelectric projects per kilowatt of installed capacity varies greatly according to type of project, size, location and many other factors. In multi-purpose projects constructed by the Federal Government the costs to be recovered by power revenues are determined by means of a cost allocation. Power is charged with the cost of all facilities specifically provided for the generation of power and with an allocated share of all facilities which are used jointly for power and other purposes.

An alternative to a proposed hydroelectric project can be almost any of the various types of power plants built and operated at the present time by the utility industry. Included among them are conventional and peaking steam-electric stations, nuclear plants, pumped storage and conventional hydro power developments, jet engine-gas turbine and diesel driven power plants. The appropriate alternative source to be used, should be, however, of the type most likely to be built in the absence of the proposed project. Furthermore, it should be of the type for which an adequate record of performance, costs and physical characteristics is readily available. Capital costs per kilowatt of capacity for modern large unit size and efficient steam-electric stations such as are being built in the area under consideration range between $110 and $130 per kilowatt of installed capacity.

Valuation of the output of a proposed hydroelectric project based on types of alternative sources other than steam-electric, is considerably more complex and requires a more advance formulation of their physical and operating characteristics than is usually the case with standard steam-electric stations. However, their use for valuation purposes may become more common in the future as more of them are employed by the utility industry for serving that peaking portion of the load, which is similar in purpose to the function of the hydroelectric project proposed for construction.

SECTION VII

WATER REQUIREMENTS FOR THERMAL ELECTRIC GENERATION

General

The largest industrial demand on the water resources of the Ohio River Basin is that of thermal electric generation. Steam-electric power plants withdraw more water than any other industry and nearly all of the withdrawals are for cooling and condensing the steam used to produce electric energy. The cooling water circulates through the power plant condensers and absorbs most of the heat retained by the steam after it leaves the turbine and before the condensate is returned to the feedwater heaters and boilers. The quantities of water required for this purpose depend on plant size, plant heat rate or thermal efficiency, and acceptable temperature rise of the cooling water. Returned to a stream with insignificant losses, the heated water contributes to thermal pollution through the reduction of the water's capacity to hold dissolved oxygen. This in turn adversely affects aquatic life, waste elimination, and the use of the water for other purposes. Recirculating the condensing water through reservoirs reduces the withdrawals but increases its consumptive use. Cooling towers as means of dissipating the heat absorbed by the cooling water also reduce withdrawals but contribute to even greater consumptive water use.

A thermal electric plant as a device for converting the chemical energy of a fuel into electrical energy at the terminals of an electric generator incurs considerable energy losses at the various stages of the conversion process. Economic and technological reasons cause the greatest losses to take place in the condenser where a little less than one-half of the original heat input is removed by the cooling water. Higher thermal efficiencies, equivalent to lower heat rates in Btu per kilowatt-hour, reduces the quantities of waste heat to be removed by the cooling water. Considerable progress has been achieved in this respect in the last 20 years. Modern steam-electric stations have heat rates of 8,500 Btu per kilowatt-hour or thermal efficiencies of 40 percent. At this efficiency, the heat removed by the cooling water is approximately 4,200 Btu per kilowatt-hour. Further gains in steam-electric thermal efficiencies are likely to be moderate because of technological reasons and because still higher pressures and temperatures would not be economically justifiable. It is expected, nevertheless, that 7,500 Btu per kilowatt-hour may be achieved by 1980. This and the gradual retirement of the old and less efficient installations will help effectively to reduce the overall requirements for cooling water.

The acceptable temperature rise for the cooling water as it circulates through the condenser is determined by plant design economics and existing regulations on thermal pollution of surface water supplies. Experience indicates that at most steam-electric power plants the acceptable temperature rise is 13°F. To remove 4,200 Btu per kilowatt-hour at full capacity operation of a modern steam-electric station would require a flow through its condenser of

$$\frac{4200 \times 1000}{13 \times 3600 \times 62.4} = 1.4 \text{ cubic feet per second for each megawatt (1000 Kw) of the plant's capacity}$$

At a lower permissible temperature rise, the required flow would be correspondingly higher.

Types of Cooling

The desired cooling water supply can be obtained by one of the following methods:

1. Once-through circulation from streams, large lakes and the ocean.
2. Recirculation from reservoirs and ponds.
3. Evaporative cooling towers.
4. Non-evaporative cooling towers.

The once-through method is the most economical and is employed where adequate flows are available, such as for plant locations on major rivers, the Great Lakes or the Atlantic and Pacific oceans. In the case of streams, the minimum flows must be at least twice the cooling water withdrawals to limit the stream's temperature rise to a maximum of 7°F. The heat added to the stream is usually dissipated rapidly through surface evaporation.

For other plants the most economical sources of cooling waters are natural or artificial reservoirs or ponds. The cooling water is taken from these impoundments and returned to them after having circulated through the condenser. The heat added to the reservoir increases surface evaporation and causes added water loss which must be replaced by adequate inflows. It is estimated that the water lost by this method of cooling amounts to approximately 0.015 cubic feet per second for each one thousand kilowatts of plant generating capacity. For proper heat dissipation the surface area of a pond, used for cooling purposes only, should be no less than 1 to 2 acres

per megawatt. In the case of multiple-purpose reservoirs also used as a source of cooling water, the surface area required should be no less than 4 to 6 acres per megawatt of plant capacity.

When neither streams nor water impoundments are available, steam-electric stations employ evaporative cooling towers to lower the temperature of the condensing water. The heated water is cooled by the forced circulation of air through a falling spray of water. Withdrawals from streams, reservoirs or ground-water sources are needed to replace evaporation and spray drift losses. The consumptive water use of power plants using cooling towers is about 0.02 cfs per megawatt of plant capacity.

Non-evaporative cooling towers dissipate to air the heat absorbed by the cooling water, using a closed piping or radiator system. Such devices are expensive to install and are not likely to be used by the multi-million kilowatt generating stations of the future.

Electric power generation utilizing nuclear fission as fuel is carried out with steam pressures and temperatures lower than those in use at modern fossil fuel plants and are operated therefore at lower thermal efficiencies. The cooling water requirements of nuclear plants are some 30 percent higher and so is their consumptive water use.

Present and Expected Future Cooling Water Requirements

At the end of 1963 the installed capacity of all utility steam-electric stations in the Ohio River Basin amounted to some 28 million kilowatts, of which nearly 90 percent used the once-through method for steam condensing purposes. A small number of plants used recirculation from reservoirs and ponds and some 2.2 million kilowatts used evaporative cooling towers. The consumptive water use for the latter group of plants came from nearby streams and in one instance from deep wells. Additions to existing plants scheduled for the near future will require in some cases the construction of cooling towers to supplement the withdrawals from nearby streams. This combination of cooling methods is likely to become more common in the future.

Table 13 shows the average and low stream flows at selected locations in the Ohio River and Tributary Basins. The reported flows indicate that available water resources in this area, can readily provide present cooling water requirements and support substantially greater thermal generation in the near future along the Ohio River and several major tributary streams without creating serious thermal pollution problems or affecting adversely other water uses.

In 1980, the expected utility generating capacity in thermal-electric stations of the Basin is estimated at some 75 million kilowatts (See Table 11). Included in this total are some 23 million kilowatts which are in operation at the present time and which will not reach retirement by 1980. There will also be some 52 million kilowatts of thermal capacity placed in service after 1963.

It is assumed for the purposes of this study that most of the thermal capacity located on the Upper, Middle and Lower Ohio will have no difficulty in using the once-through method of cooling. The same method will be used also by many new installations on the principal tributaries. Thus, by 1980 some 50 million kilowatts of thermal capacity in the Ohio River Basin are likely to obtain their requirements for cooling water in the conventional way. The remaining 25 million kilowatts will use water impoundments or evaporative cooling towers for cooling purposes with all consumptive water use readily obtainable from either surface or ground water resources.

The evaluation of the cooling and consumptive water requirements for steam-electric generation beyond 1980 or 1985, is difficult and uncertain and the results would be inadequate for most purposes. The actual geographic distribution and composition of the distant future electric power supply will be influenced to a large extent by many technological and economic developments difficult to ascertain. Principal among them are: new methods of electric power generation such as thermionic, magnetohydrodynamic, controlled nuclear fusion, and others; growth in generating unit and plant sizes; high voltages of AC and DC transmission; power pooling and coordination among utilities over wide areas; air and thermal water pollution restrictions; and the use of sewage effluent for cooling purposes. Some of the new methods of direct electric power generation eliminate the steam-electric cycle and with it the need for cooling water. In the same category is the expected increase in use of gas-turbine and jet-engine driven generators where the prime movers offer significant economic advantages over conventional steam-electric stations in serving peaking portions of load. Further capital and annual cost reductions of nuclear fission power plants may justify their use in larger numbers in areas adjacent to the Ohio River Basin to provide a supply of power to markets which previously depended on mine-mouth generation and long distance high voltage power transmission from plants within the basin.

These and numerous other factors limit the general advance planning of utility power supply to periods of 15 to 20 years. Because of the large investments involved in individual power stations, the alternatives available for the purpose, and the fairly short period of time required for plant construction, final decisions as to type, location and other important physical characteristics of new thermal stations are usually made only a few years before actual work begins.

It follows, therefore, that for the more distant periods of the future, even with reasonable evaluations of the expected demand for power, the identification at the present time of the specific forms of generation that may be used is difficult and uncertain. The same is true of the evaluation of cooling water requirements for future years such as 1985 and beyond.

Table 1

Ohio River Basin Study

Past and Estimated Future Power Requirements of Utility Market Area

Year	Energy Requirements (Million Kwh)	Peak Demand (Thousand Kw)	Load Factor %
1950	42,495	7,562	64.2
1960	106,273	17,102	70.8
1963	120,227	19,709	69.6
1970	162,650	27,910	66.5
1980	315,950	53,760	67.1
1990	551,400	93,700	67.2
2000	879,500	149,000	67.4
2010	1,281,800	216,700	67.5
2020	1,725,800	290,700	67.8

Table 2

Ohio River Basin Study

Past and Estimated Future Power Requirements of Utility Market Area
(By Power Supply Areas)

Year	PSA - 7		PSA - 9		PSA - 10	
	Energy (Million Kwh)	Peak Demand (Thousand Kw)	Energy (Million Kwh)	Peak Demand (Thousand Kw)	Energy (Million Kwh)	Peak Demand (Thousand Kw)
1950	9,331	1,692	12,370	2,255	5,176	914
1960	14,838	2,595	43,874	6,320	9,585	1,604
1963	16,859	2,930	47,834	7,125	11,534	1,948
1970	26,250	4,330	55,000	8,760	17,900	2,910
1980	42,550	7,020	117,750	18,630	31,750	4,950
1990	69,500	11,400	211,500	33,500	56,500	8,800
2000	110,000	17,900	339,000	53,700	90,300	14,100
2010	159,700	25,750	492,300	78,050	131,000	20,500
2020	215,500	34,400	664,200	105,300	176,800	27,600

Table 2

Ohio River Basin Study

Past and Estimated Future Power Requirements of Utility Market Area
(By Power Supply Areas)

Year	PSA - 12 Energy (Million Kwh)	PSA - 12 Peak Demand (Thousand Kw)	PSA - 19 Energy (Million Kwh)	PSA - 19 Peak Demand (Thousand Kw)	PSA - 40 Energy (Million Kwh)	PSA - 40 Peak Demand (Thousand Kw)
1950	13,074	2,152	1,425	318	1,118	231
1960	25,710	4,694	3,364	672	8,904	1,222
1963	30,589	5,560	4,018	837	9,393	1,311
1970	49,840	9,380	6,600	1,300	7,060	1,240
1980	94,630	18,060	13,200	2,500	16,070	2,640
1990	167,600	31,800	22,700	4,200	23,600	4,000
2000	270,200	50,800	35,900	6,500	34,100	6,000
2010	399,500	74,600	52,100	9,300	47,200	8,500
2020	538,000	100,000	70,300	12,400	61,000	11,000

Table 3

Ohio River Basin Study

Distribution of Market Requirements by Class of Service
(Million Kwh)

Class of Service	Years 1950	1960	1963	1970	1980
Rural & Residential	7,973	20,572	23,912	38,614	71,739
Commercial	5,658	11,011	13,039	20,080	36,072
Industrial	22,149	63,459	70,465	83,979	170,059
All Other	1,695	3,263	3,678	5,444	9,259
Total Deliveries	37,475	98,305	111,094	148,117	287,129
Losses	5,020	7,968	9,133	14,533	28,821
Total Energy Required	42,495	106,273	120,227	162,650	315,950

Table 4

Ohio River Basin Study

Distribution of Market Requirements by Power Supply Areas and Class of Service
(Millions of Kwh)

Class of Service	Years 1950	1960	1963	1970	1980
PSA 7					
Rural & Residential	1,380	3,324	3,490	6,900	12,280
Commercial	1,316	2,419	2,879	4,270	7,230
Industrial	5,421	7,612	8,932	12,440	19,070
All Other	308	282	294	410	560
Total Deliveries	8,425	13,637	15,595	24,020	39,140
Losses	906	1,201	1,264	2,230	3,410
Total Energy Requirements	9,331	14,838	16,859	26,250	42,550
PSA 9					
Rural & Residential	2,351	5,880	6,826	10,660	21,670
Commercial	1,408	3,024	3,271	5,140	9,770
Industrial	6,752	31,416	33,686	33,580	73,850
All Other	368	907	1,134	1,320	2,340
Total Deliveries	10,879	41,227	44,917	50,700	107,630
Losses	1,491	2,647	2,917	4,300	10,120
Total Energy Requirements	12,370	43,874	47,834	55,000	117,750
PSA 10					
Rural & Residential	756	2,088	2,521	4,300	7,210
Commercial	408	866	1,074	1,670	2,470
Industrial	3,172	5,439	6,356	9,710	18,190
All Other	108	201	273	380	670
Total Deliveries	4,444	8,594	10,224	16,060	28,540
Losses	732	991	1,310	1,840	3,210
Total Energy Requirements	5,176	9,585	11,534	17,900	31,750

Table 4

Ohio River Basin Study

Distribution of Market Requirements by Power Supply Areas and Class of Service
(Millions of Kwh)

Class of Service	Years 1950	1960	1963	1970	1980
PSA 12					
Rural & Residential	2,765	7,379	8,797	12,809	23,034
Commercial	2,165	3,862	4,868	7,526	13,627
Industrial	5,887	10,508	12,577	21,880	43,719
All Other	796	1,580	1,583	2,814	4,862
Total Deliveries	11,613	23,329	27,825	45,029	85,242
Losses	1,461	2,381	2,764	4,811	9,388
Total Energy Requirements	13,074	25,710	30,589	49,840	94,630
PSA 19					
Rural & Residential	447	1,281	1,546	2,740	5,400
Commercial	218	549	595	950	2,000
Industrial	430	910	1,115	1,780	3,676
All Other	90	192	258	320	500
Total Deliveries	1,185	2,932	3,514	5,790	11,576
Losses	241	430	504	810	1,624
Total Energy Requirements	1,426	3,362	4,018	6,600	13,200
PSA 40					
Rural & Residential	274	620	732	1,205	2,145
Commercial	143	291	352	524	975
Industrial	487	7,574	7,799	4,589	11,554
All Other	25	101	136	200	327
Total Deliveries	929	8,586	9,019	6,518	15,001
Losses	189	318	374	542	1,069
Total Energy Requirements	1,118	8,904	9,393	7,060	16,070

Table 5

Ohio River Basin Study

Utility Generating Capacity and Generation in Market Area

Installed Capacity as of December 31, 1963 - Thousand Kw

PSA	Hydro	Steam	Internal Combustion	Total
7	51	3,283 1/	8	3,342
9	-	7,642	40	7,682
10	164	2,340	-	2,504
12	98	8,778 2/	51	8,927
19	30	1,032	8	1,070
40	-	1,566	37	1,603
Total Capacity	343	24,641	144	25,128
In Ohio Basin	327	23,610	130	24,067
Net Generation in 1963 - Millions Kwh				
7	108	18,325	18	18,451
9	-	39,189	106	39,295
10	479	14,556	-	15,035
12	385	41,612	67	42,064
19	46	3,254	15	3,315
40	-	10,783	82	10,865
Total Generation	1,018	127,719	288	129,025
In Ohio Basin	985	121,790	238	123,013

1/ Includes 100 Mw in Shippingport Nuclear Fission Plant.

2/ Includes 11.4 Mw in Piqua Nuclear Fission Plant.

Table 6

Ohio River Basin Study

Principal Utility Systems, In Market Area

Principal Systems 1/	1963 Energy Requirements (Million Kwh)	1963 Installed Capacity (Megawatts)
Allegheny Power System		
Monongahela Power Co.	3,189.2	594.3
West Penn Power Co (Part)	5,952.3	1,446.6
American Electric Power Co.		
Appalachian Division	11,378.4	2,594.1
Ohio Division	15,181.4	2,774.5
Indiana-Michigan Division (Part)	2,801.0	978.0
Anderson Municipal, Indiana	240.3	19.0
Central Illinois Public Service Co. (Part)	1,456.4	212.5
Cincinnati Gas & Electric Co., The	6,148.0	1,524.0
Columbus Municipal, Ohio	124.2	45.5
Columbus and Southern Ohio Electric Co.	3,314.0	971.5
Cuyahoga Falls Municipal, Ohio	118.3	-
Dayton Power and Light Co., The	3,790.4	858.1
Duquesne Light Company	7,618.0	1,288.5
East Kentucky Rural Electric Coop. Corp.	703.4	196.0
Electric Energy, Inc. 2/	6,520.6	1,100.3
Hamilton Municipal, Ohio	192.3	66.8
Illinois Power Co. (Part)	668.8	189.8
Indianapolis Power & Light Co.	3,758.1	832.3
Kentucky Utilities Co.	2,506.6	792.1
Logansport Municipal, Indiana	104.3	30.5
Louisville Gas & Electric Co.	3,623.2	1,003.1
Northern Indiana Public Service Co. (Part)	202.6	17.7
Ohio Edison Company	9,696.5	2,345.8
Ohio Valley Electric Corp. 2/	16,152.0	2,389.9
Owensboro Municipal, Ky.	196.3	52.5
Pennsylvania Power Co.	1,653.0	293.0
Public Service Company of Indiana	5,626.7	1,706.9
Richmond Municipal, Indiana	272.4	70.0
South Central Rural Electric Coop., Inc., Ohio	189.6	-
Southern Indiana Gas & Electric Co.	1,024.5	182.2
Wayne-White Counties Electric Coop., Ill.	112.6	-
Total Principal Systems	114,515.4	24,575.5
Percent of Total Market	95.2	97.8

1/ All systems with energy requirments of 100 million kwh or more.

2/ Supplies AEC load.

Table 7

Ohio River Basin Study

Scheduled Capacity Additions for Market Area Supply

Name of Plant	Prime Mover	Installed Capacity Mw	Owner	Year Installed
A - Allegheny River Basin				
Aspinwall	I.C.	1.0	Aspinwall Municipal, Pa.	1964
B - Monongahela River Basin				
Fort Martin #1	Steam	540.0	Monongahela Pwr. Co., Potomac Edison Co. Duquesne Light Co.	1967
Fort Martin #2	Steam	540.0	West Penn Power, Monongahela Pwr. Co.	1969
C - Beaver River Basin				
New Castle	Steam	139.8	Pennsylvania Power Co.	1964
D - Upper Ohio River				
East Palestine	Steam	7.5	East Palestine Municipal, Ohio	1964
Cardinal #1	Steam	615.0	Ohio Power Co.	1966
Cardinal #2	Steam	615.0	Buckeye Power Inc.	1967
Sammis #5	Steam	315.0	Ohio Edison Co.	1967
Sammis #6	Steam	600.0	Ohio Edison Co.	1968
E - Muskingum River Basin				
Shelby	I.C.	3.0	Shelby Municipal, Ohio	1964
Shelby #4	Steam	12.5	Shelby Municipal, Ohio	1966
Orrville	Steam	7.5	Orrville Municipal, Ohio	1967
Dover	Steam	15.0	Dover Municipal, Ohio	1970

Table 7

Ohio River Basin Study

Scheduled Capacity Additions for Market Area Supply

Name of Plant	Prime Mover	Installed Capacity Mw	Owner	Year Installed
F - Kanawha-Little Kanawha River Basin - None				
G - Guyandot-Big Sandy River Basin - None				
H - Scioto River Basin				
Columbus	I.C. 1/	12.5	Columbus Municipal, Ohio	1965
I - Miami-Little Miami River Basin				
Troy	Steam	14.4	Troy Municipal, Ohio	1964
Reading	I.C.	4.0	Reading Municipal, Ohio	1965
Miamisburg	I.C. 1/	1.2	Miamisburg Municipal, Ohio	1965
Saint Marys	Steam	10.0	Saint Marys Municipal, Ohio	1965
Lebanon	I.C. 2/	6.0	Lebanon Municipal, Ohio	1965
Hamilton	Steam	22.0	Hamilton Municipal, Ohio	1966
J - Middle Ohio River				
Tanners Creek	Steam	580.0	Indiana-Michigan Gas & Elec. Co.	1964
Dicks Creek #1	I.C. 2/	108.0	Cincinnati Gas & Elec. Co.	1965
Beckjord #6	Steam	434.0	Cincinnati Gas & Elec. Co.	1968
K - Licking-Kentucky-Salt River Basin - None				
L - White River Basin				
Petersburg	Steam	220.0	Indianapolis Pwr. & Lt. Co.	1967

Table 7

Ohio River Basin Study

Scheduled Capacity Additions for Market Area Supply

Name of Plant	Prime Mover	Installed Capacity Mw	Owner	Year Installed
M - Wabash River Basin				
Crawfordsville	Steam	12.5	Crawfordsville Municipal, Ind.	1964
Logansport	Steam	25.0	Logansport Municipal, Ind.	1964
Terre Haute	Steam	318.0	Public Service Co. of Indiana	1968
N - Lower Ohio River				
No. East #2	I.C. 1/	11.5	So. Indiana Gas and Electric Co.	1964
Elmer Smith	Steam	151.0	Owensboro Municipal, Ky.	1964
Waterside	I.C. 3/	45.0	Louisville Gas & Electric Co.	1964
Cane Run #5	Steam	180.0	Louisville Gas & Electric Co.	1966
Culley #2	Steam	93.0	So. Indiana Gas and Electric Co.	1966
Markland #1, 2, 3	Hydro	81.0	Public Service Co. of Indiana	1966
O - Green River Basin				
Sebree	Steam	80.0	Big Rivers RECC	1965
P - Cumberland River Basin				
Cooper #1	Steam	100.0	East Kentucky RECC	1964
Cooper #2	Steam	200.0	East Kentucky RECC	1969
Laurel	Hydro	61.0	U. S. Corps of Engineers	1970

Table 7

Ohio River Basin Study

Scheduled Capacity Additions for Market Area Supply

Name of Plant	Prime Mover	Installed Capacity Mw	Owner	Year Installed
Ohio River Basin				
	Hydro	142.0		
	Steam	5,847.2		
	I.C.	192.2		
Total		6,181.4		
Other River Basins		443.0		
Grand Total		6,624.4		

1/ Gas Turbine

2/ Jet Engine Gas Turbine

3/ Conversion of existing steam units

Table 8

Ohio River Basin Study

Load and Capacity in Market Area 1970, 1980
(Megawatts)

		1970	1980
Estimated Load and Reserves			
Peak Demand		27,910	53,760
Required Reserves		4,740	7,540
	Total	32,650	61,300
Existing Capacity Available for Future Loads			
Dependable fuel electric, 1963 - 24,410			
Retirements to indicated year		2,180	4,480
Net available		22,230	19,930
Dependable hydroelectric, 1963 - 240		240	240
	Total existing	22,470	20,170
Scheduled Additions			
Fuel electric		6,040	6,040
Hydroelectric		580	580
	Total scheduled	6,620	6,620
Receipts from and Deliveries to Other Markets			
Firm receipts		2,000	3,000
Firm deliveries		5,000	11,000
	Net deliveries	3,000	8,000
	Capacity available for market	26,090	18,790
Additional Capacity Required			
To be installed in Ohio River Basin		6,560	39,510
To be installed in other basins		-	3,000
	Total	6,560	42,510

Table 9

Ohio River Basin Study

Distribution of Total Generating Capacity for Market by River Basins, 1963, 1970, 1980
(Megawatts)

Tributary Drainage Basins	Installed Capacity 1963	Estimated Retirements 1964-1970	Capacity Additions 1964-1970	Total Available 1970	Estimated Retirements 1971-1980	Capacity Additions 1971-1980	Total Available 1980
A Allegheny	1,022.9	419.5	1.0	604.4	127.1	2,500.0	2,977.3
B Monongahela	1,351.8	95.2	1,080.0	2,336.6	60.0	1,500.0	3,776.6
C Beaver	645.4	41.8	139.8	743.4	89.7	-	653.7
D Upper Ohio	5,331.3	393.5	4,989.5	9,927.3	521.9	11,350.0	20,755.4
E Muskingum	2,101.0	207.0	1,153.0	3,047.0	176.0	-	2,871.0
F Kanawha-Little Kanawha	1,250.1	168.5	-	1,081.6	281.1	2,000.0	2,800.5
G Guyandot-Big Sandy	265.0	-	-	265.0	-	500.0	765.0
H Scioto	411.1	150.0	12.5	273.6	75.8	-	197.8
I Miami-Little Miami	1,196.8	93.4	57.6	1,161.0	166.5	500.0	1,494.5
J Middle Ohio	3,346.2	270.2	1,737.0	4,813.0	190.0	4,600.0	9,223.0
K Licking-Kentucky-Salt	660.6	-	-	660.6	-	1,000.0	1,660.6
L White	1,148.4	124.8	840.0	1,863.6	107.7	1,500.0	3,255.9
M Wabash	1,931.7	88.1	1,320.5	3,164.1	252.6	2,000.0	4,911.5
N Lower Ohio	3,073.9	66.0	811.5	3,819.4	174.3	3,500.0	7,145.1
O Green	263.6	-	245.0	508.6	-	1,000.0	1,508.6
P Cumberland	67.5	30.0	361.0	398.5	-	1,000.0	1,398.5
Total Ohio River Tributaries	24,067.3	2,148.0	12,748.4	34,667.7	2,222.7	32,950.0	65,395.0
Other Basins	1,060.8	32.7	443.0	1,471.1	69.4	3,000.0	4,401.7
Total	25,128.1	2,180.7	13,191.4	36,138.8	2,292.1	35,950.0	69,796.7

NOTE: Installed capacity for 1963 shown in this table is slightly different from the dependable capacity used in Table 8.

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Allegheny River Basin					
Piney	H-1	Clarion, Pa.	Pennsylvania Electric Co.	P	28.8
Jamestown	T-1	Jamestown, N.Y.	Jamestown, City of	M	57.5
Warren	T-2	Warren, Pa.	Pennsylvania Electric Co.	P	73.4
Oil City	T-3	Oil City, Pa.	Pennsylvania Electric Co.	P	16.0
Armstrong	T-4	Armstrong, Pa.	West Penn Power Co.	P	326.4
Seward	T-5	Seward, Pa.	Pennsylvania Electric Co.	P	295.3
Johnstown	T-6	Johnstown, Pa.	Bethlehem Steel Co.	I	74.5
Tarentum	T-7	Tarentum, Pa.	Tarentum Boro Mun. El. Plant	M	6.2
Springdale	T-8	Pittsburgh, Pa.	West Penn Power Co.	P	416.1
Colfax	T-9	Pittsburgh, Pa.	Duquesne Light Co.	P	262.5
Stanwix	T-10	Pittsburgh, Pa.	Duquesne Light Co.	P	5.0
Monongahela River Basin					
Lake Lynn	H-2	Lake Lynn, Pa.	West Penn Power Co.	P	51.2
Deep Creek	H-3	Sines, Md.	Pennsylvania Electric Co.	P	19.2
Homestead	T-11	Homestead, Pa.	United States Steel Corp.	I	67.3
East Pittsburgh	T-12	E. Pittsburgh, Pa.	Westinghouse Electric Corp.	I	43.1
Duquesne	T-13	Duquesne, Pa.	United States Steel Corp.	I	15.0
Thomson	T-14	Duquesne, Pa.	United States Steel Corp.	I	65.0
Clairton	T-15	Clairton, Pa.	United States Steel Corp.	I	44.0
Elrama	T-16	Elrama, Pa.	Duquesne Light Co.	P	425.0
Mitchell	T-17	Courtney, Pa.	West Penn Power Co.	P	448.7
Monessen Plant	T-18	Monessen, Pa.	Pittsburgh Steel Co.	I	6.0

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Monongahela River Basin (Cont'd.)					
Connellsville	T-19	Connellsville, Pa.	West Penn Power Co.	P	54.2
Rivesville	T-20	Rivesville, W.Va.	Monongahela Power Co.	P	174.8
Cascade	T-21	Cascade, W. Va.	Preston County Coke Co.	I	8.5
Albright	T-22	Albright, W.Va.	Monongahela Power Co.	P	194.0
			Potomac Edison Co.	P	69.0
Beaver River Basin					
Grove City	T-23	Grove City, Pa.	Grove City Mun. Elec. Plant	M	7.7
Ellwood	T-24	Ellwood City, Pa.	National Tube Co.	I	6.6
Steel Div.	T-25	Farrell, Pa.	Sharon Steel Corp.	I	7.5
New Castle	T-26	New Castle, Pa.	Pennsylvania Power Co.	P	293.0
Warren	T-27	Warren, Ohio	Republic Steel Corp.	I	7.4
Mahoningside	T-28	Warren, Ohio	Ohio Edison Co.	P	87.4
Niles	T-29	Niles, Ohio	Ohio Edison Co.	P	250.0
Youngstown	T-30	Youngstown, Ohio	United States Steel Corp.	I	45.0
Brier Hill	T-31	Youngstown, Ohio	Youngstown Sheet & Tube	I	9.0
Campbell	T-32	Campbell, Ohio	Youngstown Sheet & Tube	I	53.5
Upper Ohio River					
Pittsburgh	T-33	Pittsburgh, Pa.	Jones & Laughlin Steel	I	70.0
Pittsburgh	T-34	Pittsburgh, Pa.	Heinz, H. J. Co.	I	6.0
Neville	T-35	Pittsburgh, Pa.	Shenango, Inc.	I	10.0

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed (Capacity (Mw)
Upper Ohio River (Cont'd.)					
Reed	T-36	Pittsburgh, Pa.	Duquesne Light Co.	P	180.0
Aliquippa Works	T-37	Aliquippa, Pa.	Jones & Laughlin Steel	I	57.0
Josephtown	T-38	Monaca, Pa.	St. Joseph Lead Co.	I	100.0
Phillips	T-39	Pittsburgh, Pa.	Duquesne Light Co.	P	315.0
Shippingport	T-40	Shippingport, Pa.	Duquesne Light Co.	P	100.0
Midland Works	T-41	Midland, Pa.	Crucible Steel Co. of America	I	24.0
East Palestine	T-42	East Palestine, Ohio	E. Palestine Lt. & Water Works	M	9.0
Sammis	T-43	Stratton, Ohio	Ohio Edison Co.	P	740.0
Toronto	T-44	Toronto, Ohio	Ohio Edison Co.	P	315.8
Weirton	T-45	Weirton, W.Va.	Weirton Steel Co.	I	108.3
South Works	T-46	Steubenville, Ohio	Wheeling Steel Corp.	I	11.0
Tidd	T-47	Brilliant, Ohio	Ohio Power Co.	P	222.2
Windsor	T-48	Power, W.Va.	Ohio Power Co./West Penn Pwr. Co.	P	300.0
Martins Ferry	T-49	Martins Ferry, Ohio	Martins Ferry El. Lt. & Pwr. Plt.	M	6.5
Burger	T-50	Shadyside, Ohio	Ohio Edison Co.	P	544.0
Kammer	T-51	Captina, W.Va.	(Ormet Generating Corp.	I	450.0
			(Ohio Power Co.	P	225.0
Martinsville	T-52	New Martinsville, W.Va.	Pittsburgh Plate Glass Co.	I	54.0
Willow Island	T-53	St. Marys, W.Va.	Monongahela Power Co.	P	215.0
Marietta	T-54	Marietta, Ohio	Union Carbide Metals Co.	I	160.0
Parkersburg	T-55	Parkersburg, W.Va.	American Viscose Corp.	I	30.8
Parkersburg	T-56	Parkersburg, W.Va.	Monongahela Power Co.	P	10.0
Kyger Creek	T-57	Kyger, Ohio	Ohio Valley Electric Corp.	P	1086.3
Sporn	T-58	Point Pleasant, W.Va.	Central Operating Co.	P	1060.0
South Point	T-59	South Point, Ohio	Allied Chemical Corp.	I	15.0

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Muskingum River Basin					
Barberton	T-60	Barberton, Ohio	Pittsburgh Plate Glass Co.	I	87.0
Massillon Works	T-61	Massillon, Ohio	Republic Steel Corp.	I	10.0
Canton Works	T-62	Canton, Ohio	Republic Steel Corp.	I	13.5
Rittman	T-63	Rittman, Ohio	Packaging Corp. of America	I	14.0
Orrville	T-64	Orrville, Ohio	Orrville Municipal Utilities	M	38.5
Dover	T-65	Dover, Ohio	Dover Elec. Lt. & Power Plant	M	15.0
Conesville	T-66	Conesville, Ohio	Columbus & Southern Ohio Elec. Co.	P	433.5
Philo	T-67	Philo, Ohio	Ohio Power Co.	P	500.0
Muskingum River	T-68	Beverly, Ohio	Ohio Power Co.	P	876.0
Poston	T-69	Athens, Ohio	Columbus & Southern Ohio Elec. Co.	P	232.0
Kanawha-Little Kanawha River Basin					
Winfield	H-4	Winfield, W.Va.	Kanawha Valley Power Co.	P	14.8
Marmet	H-5	Marmet, W.Va.	Kanawha Valley Power Co.	P	14.4
London	H-6	Handley, W.Va.	Kanawha Valley Power Co.	P	14.4
Alloy	H-7	Alloy, W.Va.	Union Carbide Carbon Co.	I	102.0
Claytor	H-8	Radford, Va.	Appalachian Power Co.	P	75.0
Buck	H-9	Ivanhoe, Va.	Appalachian Power Co.	P	8.5
Byllesby	H-10	Byllesby, Va.	Appalachian Power Co.	P	21.6
Nitro	T-70	Nitro, W.Va.	American Viscose Corp.	I	17.5
Institute	T-71	Institute, W.Va.	Union Carbide Corp.	I	10.0
Belle	T-72	Belle, W.Va.	Dupont de Nemours Co., E.I.	I	7.5
Charleston	T-73	Charleston, W.Va.	Food Machinery & Chemical Corp.	I	40.0
Charleston	T-74	Charleston, W.Va.	Union Carbide Carbon Co.	I	28.5

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Kanawha-Little Kanawha River Basin					
Cabin Creek	T-75	Cabin Creek, W.Va.	Appalachian Power Co.	P	273.5
Kanawha River	T-76	Glasgow, W.Va.	Appalachian Power Co.	P	426.0
Alloy Works	T-77	Alloy, W.Va.	Union Carbide Metals Co.	I	123.0
Rainelle	T-78	Rainelle, W.Va.	Meadow River Lumber Co.	I	6.6
Glen Lyn	T-79	Glen Lyn, Va.	Appalachian Power Co.	P	401.1
Celco	T-80	Narrows, Va.	Celanese Corp. of America	I	18.0
Radford Arsenal	T-81	Radford, Va.	U. S. Army	F	24.0
Guyandot-Big Sandy River Basin					
Big Sandy	T-82	Louisa, Ky.	Kentucky Power Co.	P	265.0
Ashland	T-83	Ashland, Ky.	Allied Chemical Corp.	I	5.0
Scioto River Basin					
Scioto	T-84	Marion, Ohio	Ohio Edison Co.	P	40.3
Columbus	T-85	Columbus, Ohio	Columbus Division of Elec.	M	45.5
Columbus	T-86	Columbus, Ohio	Columbus Sewage Treatment	M	5.5
Walnut	T-87	Columbus, Ohio	Columbus & So. Ohio Elec. Co.	P	75.0
Picway	T-88	Columbus, Ohio	Columbus & So. Ohio Elec. Co.	P	230.8
Columbus	T-89	Columbus, Ohio	Ohio State University	P	14.0
Chillicothe	T-90	Chillicothe, Ohio	Mead Corporation	I	48.1
Portsmouth	T-91	Portsmouth, Ohio	Detroit Steel Corp.	I	21.5

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Miami-Little Miami River Basin					
Bellefontaine	T-92	Bellefontaine, Ohic	Bellefontaine, Ohio	M	6.0
Piqua	T-93	Piqua, Ohio	Piqua, Ohio	M	53.0
Troy	T-94	Troy, Ohio	Troy, Ohio	M	15.0
Rockaway	T-95	Springfield, Ohio	Ohio Edison Co.	P	13.0
Mad River	T-96	Springfield, Ohio	Ohic Edison Co.	P	75.0
Tait, F. M.	T-97	Dayton, Ohio	Dayton Power & Light Co.	P	444.1
Dayton	T-98	Dayton, Ohio	National Cash Register Co.	I	16.4
Oxford Miami	T-99	West Carrollton, Ohio	Oxford Paper Co.	I	9.1
Miamisburg	T-100	Miamisburg, Ohio	Miamisburg, Ohio	M	6.4
Hutchings, O.H.	T-101	Miamisburg, Ohio	Dayton Power and Light Co.	P	414.0
Middletown	T-102	Middletown, Ohio	Sorg Paper Co.	I	17.5
Middletown	T-103	Middletown, Ohio	Armco Steel	I	15.3
Lebanon	T-104	Lebanon, Ohio	Lebanon, Ohio	M	8.7
Mills Carton	T-105	Middletown, Ohio	Diamond Gardner Corp.	I	6.0
Hamilton	T-106	Hamilton, Ohio	Hamilton, Ohio	M	70.3
Hamilton	T-108	Hamilton, Ohio	Champion Papers Inc.	I	24.5
Reading	T-109	Reading, Ohio	Reading, Ohio	M	11.5
Lockland	T-110	Lockland, Ohio	Carey Philip Manufacturing Co.	I	7.5
Ivorydale	T-111	St. Bernard, Ohio	Procter & Gamble Manufacturing Co.	I	6.5
White Water	T-112	Richmond, Ind.	Richmond, Ind.	M	30.0
Richmond (Johnson St.)	T-113	Richmond, Ind.	Richmond, Ind.	M	40.0

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Middle Ohio River Basin					
Beckjord, W. C.	T-114	New Richmond, Ohio	Cincinnati Gas & Electric Co.	P	760.5
West End	T-115	Cincinnati, Ohio	Cincinnati Gas & Electric Co.	P	224.3
Miami Fort	T-116	North Bend, Ohio	Cincinnati Gas & Electric Co.	P	539.2
Tanners Creek	T-117	Lawrenceburg, Ind.	Indiana-Michigan Electric Co.	P	518.0
Clifty Creek	T-118	Madison, Ind.	Ohio Valley Electric Co.	P	1304.0
Licking-Kentucky-Salt River Basin					
Dix Dam	H-11	High Bridge, Ky.	Kentucky Utilities Co.	P	28.3
Paris	T-119	Paris, Ky.	Paris, Kentucky	M	5.6
Dale, W. C.	T-120	Winchester, Ky.	East Kentucky, RECC	C	196.0
Brown, E. W.	T-121	Burgin, Ky.	Kentucky Utilities Co.	P	293.2
Tyrone	T-122	Tyrone, Ky.	Kentucky Utilities Co.	P	137.5
White River Basin					
Anderson	T-123	Anderson, Ind.	Anderson, Ind.	M	19.0
Noblesville	T-124	Noblesville, Ind.	Public Service Co. of Indiana	P	100.0
Perry, W.	T-124	Indianapolis, Ind.	Indianapolis Power & Light Co.	P	10.0
Perry, K.	T-126	Indianapolis, Ind.	Indianapolis Power & Light Co.	P	47.5
Stout, Elmer	T-127	Indianapolis, Ind.	Indianapolis Power & Light Co.	P	381.1
Allison	T-128	Indianapolis, Ind.	General Motors Corp.	I	6.8
Pritchard, H. T.	T-129	Centerton, Ind.	Indianapolis Power & Light Co.	P	393.6
Edwardsport	T-130	Edwardsport, Ind.	Public Service Co. of Indiana	P	159.0
Washington	T-131	Washington, Ind.	Washington, Ind.	M	18.0
Jasper	T-132	Jasper, Ind.	Jasper, Ind.	M	9.5
Rushville	T-133	Rushville, Ind.	Rushville, Ind.	M	8.3

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Wabash River Basin					
Norway	H-12	Norway, Ind.	North Indiana Public Service	P	6.7
Oakdale	H-13	Yeoman, Ind.	North Indiana Public Service	P	11.0
St. Marys	T-134	St. Marys, Ohio	St. Marys	M	12.0
Celina	T-135	Celina, Ohio	Celina, Ohio	M	12.5
Portland	T-136	Portland, Ind.	Indiana-Michigan Gas & Elec. Co.	P	10.0
Bluffton	T-137	Bluffton, Ind.	Bluffton, Indiana	M	7.0
Peru	T-138	Peru, Ind.	Peru, Indiana	M	40.0
Logansport	T-139	Logansport, Ind.	Logansport, Ind.	M	30.0
Frankfort	T-140	Frankfort, Ind.	Frankfort, Ind.	M	36.0
Crawfordsville	T-141	Crawfordsville, Ind.	Crawfordsville, Ind.	M	27.5
Rantoul	T-142	Rantoul, Ill	Rantoul, Ill.	M	8.0
Vermilion	T-143	Oakwood, Ill.	Illinois Power Company	P	182.3
Danville	T-144	Danville, Ill.	Illinois Power Company	P	7.5
Dresser	T-145	Terre Haute, Ind.	Public Service Company of Indiana	P	210.0
Wabash River	T-146	West Terre Haute, Ind.	Public Service Company of Indiana	P	575.0
Terre Haute	T-147	Terre Haute, Ind.	Columbian Enameling Stamp Co.	I	6.0
Marshall	T-148	Marshall, Ill.	Marshall, Ill.	M	5.6
Hutsonville	T-149	Hutsonville, Ill.	Central Illinois Public Service Co.	P	212.5
Breed	T-150	Sullivan, Ind.	Indiana-Michigan Gas & Elec. Co.	P	450.0
Robinson	T-151	Robinson, Ill.	Marathon Oil Co.	I	12.0
University of Ill.	T-152	Champaign, Ill.	University of Illinois	S	30.0
Tuscola	T-153	Tuscola, Ill.	U.S. Industrial Chemical Corp.	I	12.5
Mt. Carmel	T-154	Mt. Carmel, Ill.	Mt. Carmel Public Utilities Co.	P	20.5
Fairfield	T-155	Fairfield, Ill.	Fairfield, Ill.	M	12.5
Carmi	T-156	Carmi, Ill.	Carmi, Ill.	M	10.2

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Lower Ohio River Basin					
Ohio Falls	H-14	Louisville, Ky.	Louisville Gas & Electric Co.	P	80.3
Charlestown	T-157	Charlestown, Ind.	Olin Mathieson Chemical Corp.	I	55.0
Speed	T-158	Speed, Ind.	Louisville Cement Corp.	I	6.5
Gallagher	T-159	New Albany, Ind.	Public Service Company of Indiana	P	660.0
Waterside	T-160	Louisville, Ky.	Louisville Gas & Electric Co.	P	45.0
Canal	T-161	Louisville, Ky.	Louisville Gas & Electric Co.	P	50.0
Paddy's Run	T-162	Louisville, Ky.	Louisville Gas & Electric Co.	P	337.5
Cane Run	T-163	Louisville, Ky.	Louisville Gas & Electric Co.	P	535.3
Kosmosdale	T-164	Louisville, Ky.	Kosmos Portland Cement Co.	I	9.5
Owensboro	T-165	Owensboro, Ky.	Owensboro, Ky.	M	52.5
Huntingburg	T-166	Huntingburg, Ind.	Huntingburg, Ind.	M	6.8
Culley	T-167	Yankeetown, Ind.	Southern Indiana Gas & Electric Co.	P	50.0
Warrick	T-168	Newburgh, Ind.	Alcoa Generating Corp.	I	125.0
Northeast, G.T.	T-169	Evansville, Ind.	Southern Indiana Gas & Electric Co.	P	10.7
Ohio River	T-170	Evansville, Ind.	Southern Indiana Gas & Electric Co.	P	121.5
Henderson	T-171	Henderson, Ky.	Henderson, Ky.	M	24.0
Shawnee	T-172	Paducah, Ky.	Tennessee Valley Authority	F	1500.0
Joppa	T-173	Joppa, Ill.	Electric Energy, Inc.	P	1100.3
Green River Basin					
Paradise	T-174	Paradise, Ky.	Tennessee Valley Authority	F	1408.0
Green River	T-175	South Carrolton, Ky.	Kentucky Utilities Co.	P	263.6
Henderson	T-176	Henderson, Ky.	Spencer Chemical Co.	I	10.5

Table 10

Ohio River Basin Study

Principal Utility & Non-Utility Plants in the Basin, 1963
(5 Megawatts and Over)

Name of Plant	Map Symbol	Location	Owner	Type	Installed Capacity (Mw)
Cumberland River Basin					
Wolf Creek	H-15	Creelsboro, Ky.	Corps of Engineers	F	270.0
Dale Hollow	H-16	Celina, Tenn.	Corps of Engineers	F	54.0
Great Falls	H-17	Rock Island, Tenn.	Tennessee Valley Authority	F	31.9
Center Hill	H-18	Buffalo Valley, Tenn.	Corps of Engineers	F	135.0
Old Hickory	H-19	Old Hickory, Tenn.	Corps of Engineers	F	100.0
Cheatham	H-20	Billsburg, Tenn.	Corps of Engineers	F	36.0
Pineville	T-177	Pineville, Ky.	Kentucky Utilities Co.	P	67.5
Gallatin	T-178	Gallatin, Tenn.	Tennessee Valley Authority	F	1050.0
Old Hickory	T-179	Old Hickory, Tenn.	Dupont & Co.	I	29.5

P - Private Utility
M - Municipal
C - Cooperative
S - State
F - Federal
I - Industrial

NOTE: Map symbols (T-thermal) and H-hydro) refer to Exhibit No. 5

Table 11

Distribution of Utility Generating Capacity in the Ohio River Basin, 1963, 1970, 1980
(Megawatts)

	Tributary Drainage Basins	1963			1970			1980		
		Fuel	Hydro	Total	Fuel	Hydro	Total	Fuel	Hydro	Total
A	Allegheny	1,465.1	28.8	1,493.9	5,804.1	28.8	5,832.9	8,122.0	353.8	8,475.8
B	Monongahela	1,369.6	70.4	1,440.0	2,354.4	70.4	2,424.8	3,414.4	450.4	3,864.8
C	Beaver	645.4	-	645.4	743.4	-	743.4	653.7	-	653.7
D	Upper Ohio	5,331.3	-	5,331.3	9,927.3	-	9,927.3	20,755.4	-	20,755.4
E	Muskingum	2,101.0	-	2,101.0	3,047.0	-	3,047.0	2,871.0	-	2,871.0
F	Kanawha-Little Kanawha	1,100.6	149.5	1,250.1	932.1	149.5	1,081.6	1,491.0	1,309.5	2,800.5
G	Guyandot-Big Sandy	265.0	-	265.0	265.0	-	265.0	765.0	-	765.0
H	Scioto	411.1	-	411.1	273.6	-	273.6	197.8	-	197.8
I	Miami-Little Miami	1,196.8	-	1,196.8	1,161.0	-	1,161.0	1,494.5	-	1,494.5
J	Middle Ohio	3,346.2	-	3,346.2	4,813.0	-	4,813.0	9,223.0	-	9,223.0
K	Licking-Kentucky-Salt	632.3	28.3	660.6	632.3	28.3	660.6	1,632.3	28.3	1,660.6
L	White	1,148.4	-	1,148.4	1,863.6	-	1,863.6	3,255.9	-	3,255.9
M	Wabash	1,914.0	17.7	1,931.7	3,146.4	17.7	3,164.1	4,893.8	17.7	4,911.5
N	Lower Ohio	4,493.6	80.3	4,573.9	5,158.1	161.3	5,319.4	8,483.8	161.3	8,645.1
O	Green	1,671.6	-	1,671.6	3,066.6	-	3,066.6	4,066.6	-	4,066.6
P	Cumberland	1,117.5	626.9	1,744.4	1,387.5	945.9	2,333.4	3,537.5	945.9	4,483.4
	Total Ohio River Basin	28,209.5	1,001.9	29,211.4	44.575.4	1,401.9	45,977.3	74,857.7	3,266.9	78,124.6

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

Project Name and Basin	River	State	Installed Capacity Kw	Average Annual Generation 1,000 Mwh	Gross Head Ft.
Conventional Installations					
A. Allegheny River Basin					
Foxburg	Clarion	Pa.	130,000	180	150
Mill Creek	Clarion	Pa.	110,000	175	225
Sub-Total			240,000	355	
B. Monongahela River Basin					
Dam C	Youghiogheny	Pa.	15,000	49	50
Dam B	Youghiogheny	Pa.	25,000	80	85
Dam A	Youghiogheny	Pa.	25,000	80	85
Youghiogheny	Youghiogheny	Pa.	24,000	76	126
Sang Run	Youghiogheny	Md.	48,000	153	560
Beaver Hole	Cheat	W.Va.	450,000	620	310
Tygart	Tygart	W.Va.	40,000	173	170
Laurel	Tygart	W.Va.	70,000	200	480
Sub-Total			697,000	1,431	
C. Beaver River Basin					
Dam No. 1	Connoquenessing	Pa.	45,000	59	95
Dam No. 2	Slippery Rock Creek	Pa.	13,000	20	70
Dam No. 3	Slippery Rock Creek	Pa.	25,000	35	120
Dam No. 4	Slippery Rock Creek	Pa.	17,000	26	90
Sub-Total			100,000	140	
D. Ohio - Main Stem					
Gallipolis Lock and Dam 1/	Ohio	Ohio	40,000	120	23
Racine 2/	Ohio	Ohio-W.Va.	45,000	250	22
Belleville	Ohio	Ohio-W.Va.	45,000	250	22
Willow Island	Ohio	Ohio-W.Va.	45,000	230	20
Hannibal	Ohio	Ohio-W.Va.	45,000	240	21

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

Project Name and Basin	River	State	Installed Capacity Kw	Average Annual Generation 1,000 Mwh	Gross Head Ft.
D. Ohio - Main Stem (Cont'd.)					
Pike Island	Ohio	Ohio-W.Va.	32,000	200	21
New Cumberland	Ohio	Ohio-W.Va.	32,000	200	20
Montgomery	Ohio	Pa.	30,000	190	18
Emsworth	Ohio	Pa.	22,000	87	18
Sub-Total			336,000	1,767	
E. Muskingum River Basin		- NONE -			
F. Kanawha River Basin					
Swiss	Gauley	W.Va.	20,000	110	100
Carnifex	Gauley	W.Va.	220,000	640	490
Meadow River	Meadow	W.Va.	70,000	250	680
Summersville	Gauley	W.Va.	90,000	430	370
Gauley Mills	Gauley	W.Va.	40,000	110	400
Thurmond	New	W.Va.	200,000	1,000	240
Sandstone	New	W.Va.	240,000	1,220	290
Bluestone	New	W.Va.	180,000	520	100
Foster Falls	New	Va.	20,000	140	50
Fries Junction	New	Va.	15,000	105	60
Lower Dam 3/	New	Va.	20,000	90	90
Upper Dam (Moores Ferry)3/	New	Va.	60,000	280	195
Halsey	New	N.C.	25,000	90	164
Sub-Total			1,200,000	4,985	
G. Guyandot - Big Sandy River Basin		- NONE -			
H. Scioto River Basin		- NONE -			
I. Miami River Basin					
East Fork	E.Fk. Little Miami	Ohio	10,000	32	170
Oregonia	Little Miami	Ohio	5,000	15	55
Sub-Total			15,000	47	

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

Project Name and Basin	River	State	Installed Capacity Kw	Average Annual Generation 1,000 Mwh	Gross Head Ft.
J. Ohio - Main Stem					
Markland 4/	Ohio	Ind.	81,000	450	35
Meldahl	Ohio	Ky.-Ohio	70,000	350	30
Greenup 5/	Ohio	Ky.-Ohio	70,000	340	30
Sub-Total			221,000	1,140	
K. Licking-Kentucky-Salt River Basin					
Rolling Fork Reservoir	Salt	Ky.	5,000	30	70
Lock No. 3	Kentucky	Ky.	9,400	53	25
Fincastle Reservoir	N.Fk. Kentucky	Ky.	14,400	45	70
Pools Creek	Licking	Ky.	30,000	79	50
Boston Station	Licking	Ky.	22,500	56	40
Falmouth	Licking	Ky.	100,000	255	133
Sub-Total			181,300	518	
L. White River Basin					
Petersburg	White	Ind.	25,000	130	28
Lost River	E.Fk. White	Ind.	15,000	70	28
Shoals	E.Fk. White	Ind.	30,000	110	57
Spencer	W.Fk. White	Ind.	15,000	60	54
Sub-Total			85,000	370	
M. Wabash River Basin					
Clinton	Wabash	Ind.	75,000	225	62
Danville	Vermilion	Ill.	10,000	25	60
Delphi	Wabash	Ind.	75,000	160	74
Sub-Total			160,000	410	

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

Project Name and Basin	River	State	Installed Capacity Kw	Average Annual Generation 1,000 Mwh	Gross Head Ft.
N. Ohio - Main Stem					
Mound City	Ohio	Ill.-Ky.	100,000	500	33
Smithland	Ohio	Ill.-Ky.	60,000	320	19
Uniontown	Ohio	Ind.-Ky.	60,000	320	18
Newburgh	Ohio	Ind.	50,000	170	16
Cannelton 6/	Ohio	Ky.	70,000	380	25
Sub-Total			340,000	1,690	
O. Green River Basin					
Rochester	Green	Ky.	30,000	120	38
Barren No. 2	Barren	Ky.	50,000	105	130
Nolin River Reservoir	Nolin	Ky.	22,000	59	133
Sub-Total			102,000	284	
P. Cumberland River Basin					
Barkley 7/	Cumberland	Ky.	130,000	582	52
Three Islands	Harpeth	Tenn.	18,000	45	89
J. Percy Priest 7/	Stones	Tenn.	28,000	70	98
Cordell Hull 7/	Cumberland	Tenn.	100,000	350	55
Celina	Cumberland	Ky.	108,000	227	50
Devils Jumps	Big South Fk.	Ky.	480,000	475	457
Rockcastle	Rockcastle	Ky.	48,000	44	142
Parker Branch	Rockcastle	Ky.	22,000	17	133
Laurel 7/	Laurel	Ky.	61,000	56	258
Cumberland Falls	Cumberland	Ky.	100,000	185	150
Sub-Total			1,095,000	2,051	
Grand Total - Conventional			4,772,300	15,188	

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

	Project Name and Basin	River	State	Installed Capacity Kw	Average Annual Generation 1,000 Mwh	Gross Head Ft.
		Pumped Storage Installations 8/				
A.	Allegheny River Basin					
	Kinzua (Seneca)	Allegheny	Pa.	325,000	550	798
B.	Monongahela River Basin					
	Rowlesburg 9/	Cheat	W.Va.	525,000	1,000	938
F.	Kanawha River Basin					
	Blue Ridge					
	Upper Dam 10/	New	Va.	900,000	2,265	190
I.	Miami River Basin					
	Brookville 11/	E.Fk. Whitewater	Ind.	240,000	300	327
K.	Licking-Kentucky-Salt River Basin					
	Booneville	S.Fk. Kentucky	Ky.	400,000	624	560
	Cave Run	Licking	Ky.	350,000	453	520
P.	Cumberland River Basin					
	Jellico Creek	Jellico Creek	Ky.	135,000	22	195
	Total - Pumped Storage			2,875,000	5,214	
	Grand Total - Pumped Storage and Conventional Installations			7,647,300	20,402	

Table 12

Ohio River Basin Study

Undeveloped Hydro Power by Tributary Drainage Basins

Notes:

1/ FPC Project No. 2393 - License Application filed by Columbus & Southern Ohio Electric Power Company pending.

2/ FPC Project No. 2570 - Application for Preliminary Permit filed by Ohio Power Company pending.

3/ Alternate for Blue Ridge (FPC Project No. 2317).

4/ FPC Project No. 2211 - Power Installation under construction by Public Service Company of Indiana.

5/ FPC Project No. 2571 - Application for Preliminary Permit filed by the Ohio Power Company pending.
FPC Project No. 2614 - Application for Preliminary Permit filed by City of Vanceboro, Ky. pending.

6/ FPC Project No. 2245 - License Application filed by Harrison County Rural Electric Membership Co-op pending.

7/ Under construction by Corps of Engineers.

8/ Includes only projects on which data are available.

9/ FPC Project No. 2477 - Preliminary Permit issued to Monongahela Power Company 6/22/64 for 3 year period.

10/ FPC Project No. 2317 - License Application filed by Appalachian Power Company pending - Project also includes Lower Dam with conventional installation of 80,000 Kw.

11/ FPC Project No. 2359 - Preliminary Permit issued to the Public Service Company of Indiana 12/31/63 for a 3 year period.

Table 13

Ohio River Basin Study

Stream Flow at Selected Locations on the Ohio River and Tributaries 1/

Locations	Drainage Area Sq. Miles	Average Discharge Cfs	Low Flow 7 day - 10 year Cfs
A. Allegheny River Basin			
Red House, Pa.	1,690	2,792	115
Franklin, Pa.	5,982	10,320	470
Natrona, Pa.	11,410	19,490	890
B. Monongahela River Basin			
Parsons, W. Va.	718	1,656	33
Hoult, W. Va.	2,388	4,120	99
Greensboro, Pa.	4,407	8,168	384
C. Beaver River Basin			
Sharpsville, Pa.	588	743	86
Youngstown, Ohio	899	844	120
Wampum, Pa.	2,235	2,365	232
D. Upper Ohio River			
Bellaire, Ohio	25,100	40,850	5,580
E. Muskingum River Basin			
Dover, Ohio	1,398	1,375	159
Coshocton, Ohio	4,847	4,855	464
McConnellsville, Ohio	7,411	7,282	565
F. Kanawha-Little Kanawha River Basins			
Palestine, W. Va.	1,515	2,100	36
Glenlyn, Va.	3,768	4,929	1,050
Charleston, W. Va.	10,419	14,320	1,285

Table 13

Ohio River Basin Study

Stream Flow at Selected Locations on the Ohic River and Tributaries 1/

Locations	Drainage Area Sq. Miles	Average Discharge Cfs	Low Flow 7 day - 10 year Cfs
G. Guyandot-Big Sandy River Basins			
Branchland, W. Va.	1,226	1,573	20
Paintsville, Ky.	2,143	2,385	15
Louisa, Ky.	3,892	4,228	59
H. Scicto River Basin			
Prospect, Ohio	571	449	8
Columbus, Ohio	1,624	1,336	58
Chillicothe, Ohio	3,847	3,294	185
I. Miami-Little Miami River Basins			
Alpine, Ind.	539	545	45
Milford, Ohic	1,195	1,205	42
Hamilton, Ohio	3,639	3,203	281
J. Middle Ohio River			
Maysville, Ky.	70,130	91,550	10,750
K. Licking-Kentucky-Salt River Basins			
Booneville, Ky.	722	1,028	33
Boston, Ky.	1,299	1,720	1.3
Catawba, Ky.	3,300	4,131	10.3
L. White River Basin			
Noblesville, Ind.	814	821	58
Shoals, Ind.	4,954	5,458	222
Petersburg, Ind.	11,139	11,630	685

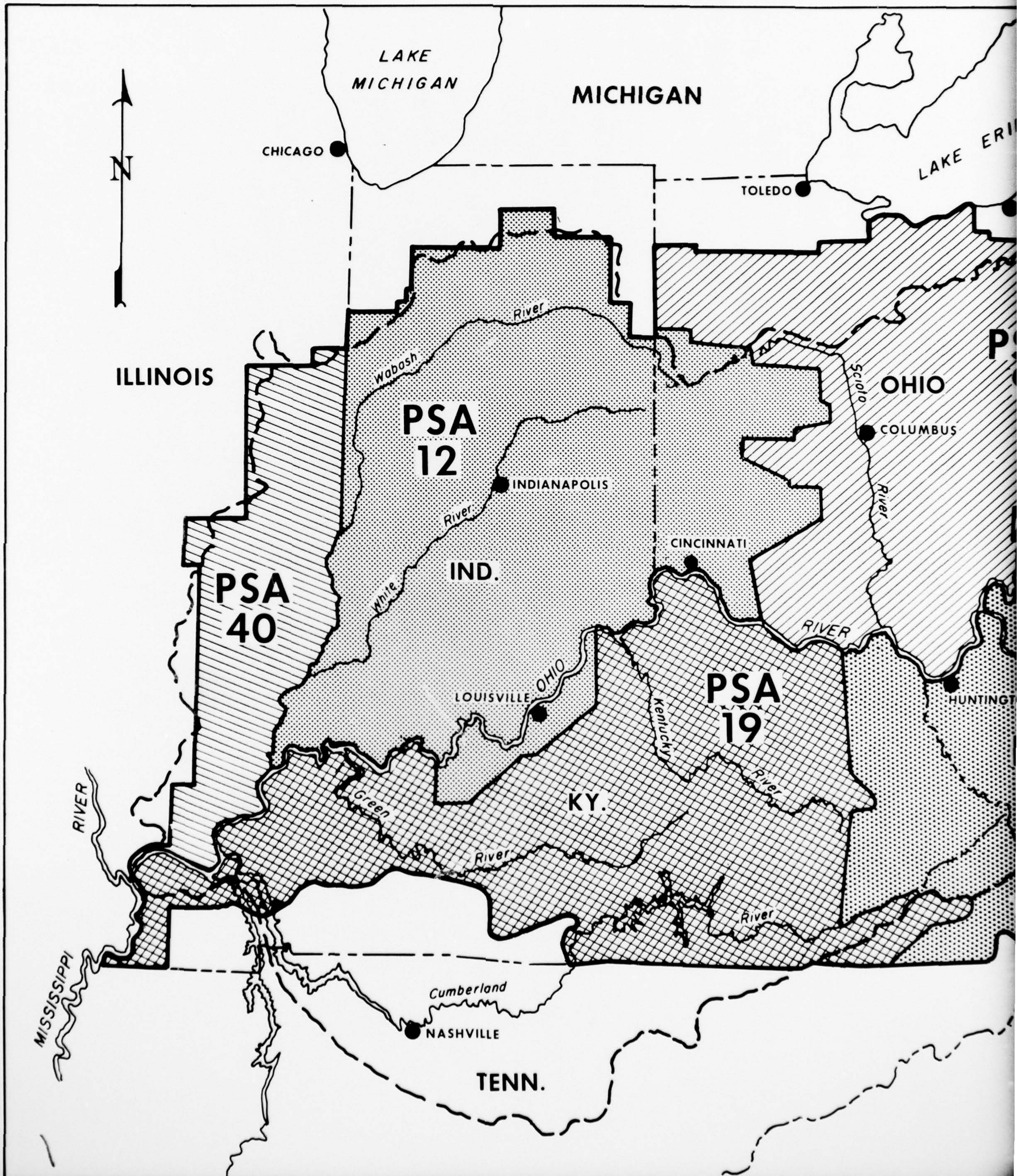
Table 13

Ohio River Basin Study

Stream Flow at Selected Locations on the Ohio River and Tributaries 1/

Locations	Drainage Area Sq. Miles	Average Discharge Cfs	Low Flow 7 day - 10 year Cfs
M. Wabash River Basin			
Wabash, Ind.	1,733	1,511	26
Lafayette, Ind.	7,247	6,401	535
Vincennes, Ind.	13,700	11,550	1,060
N. Lower Ohio River			
Louisville, Ky.	91,170	113,700	12,450
Evansville, Ind.	107,000	133,000	16,200
O. Green River Basin			
Greensburg, Ky.	736	1,086	1.7
Bowling Green, Ky.	1,848	2,464	53
Calhoun, Ky.	7,564	10,850	306
P. Cumberland River Basin			
Barbourville, Ky.	960	1,722	8.3
Carthage, Tenn.	10,700	17,020	3,125
Smithland, Ky.	17,913	27,920	4,100

1/ Source of data - Appendix C Hydrology (Table 15).



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TOLEDO
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N
ILLINOIS
Wabash
River
PSA 12
INDIANAPOLIS
River
White
IND.
OHIO
Scioto
River
COLUMBUS
CINCINNATI
PSA 40
RIVER
LOUISVILLE
OHIO
PSA 19
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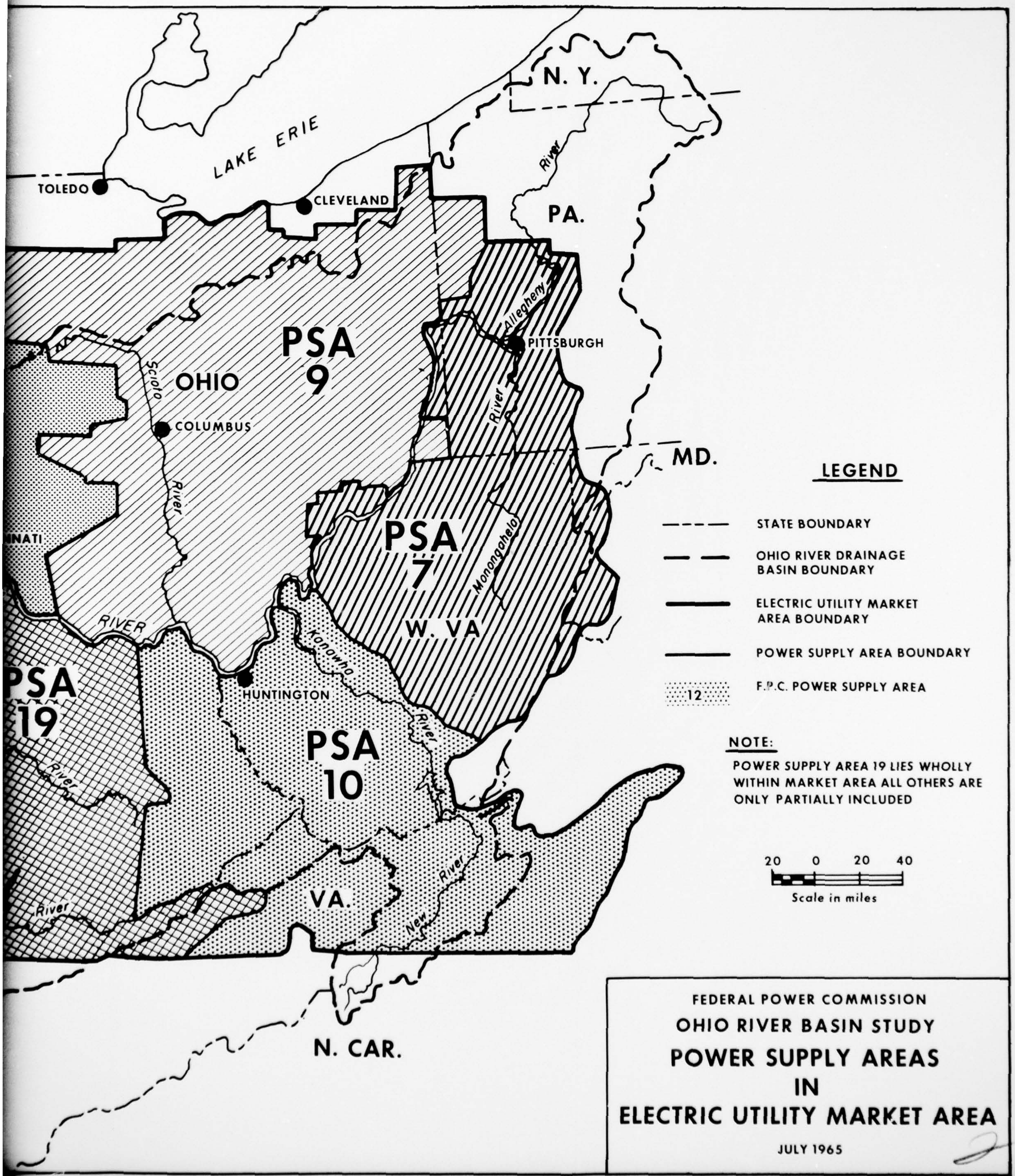
KY.
Green
River
River
HUNTINGT
RIVER
MISSISSIPPI
Cumberland
NASHVILLE
TENN.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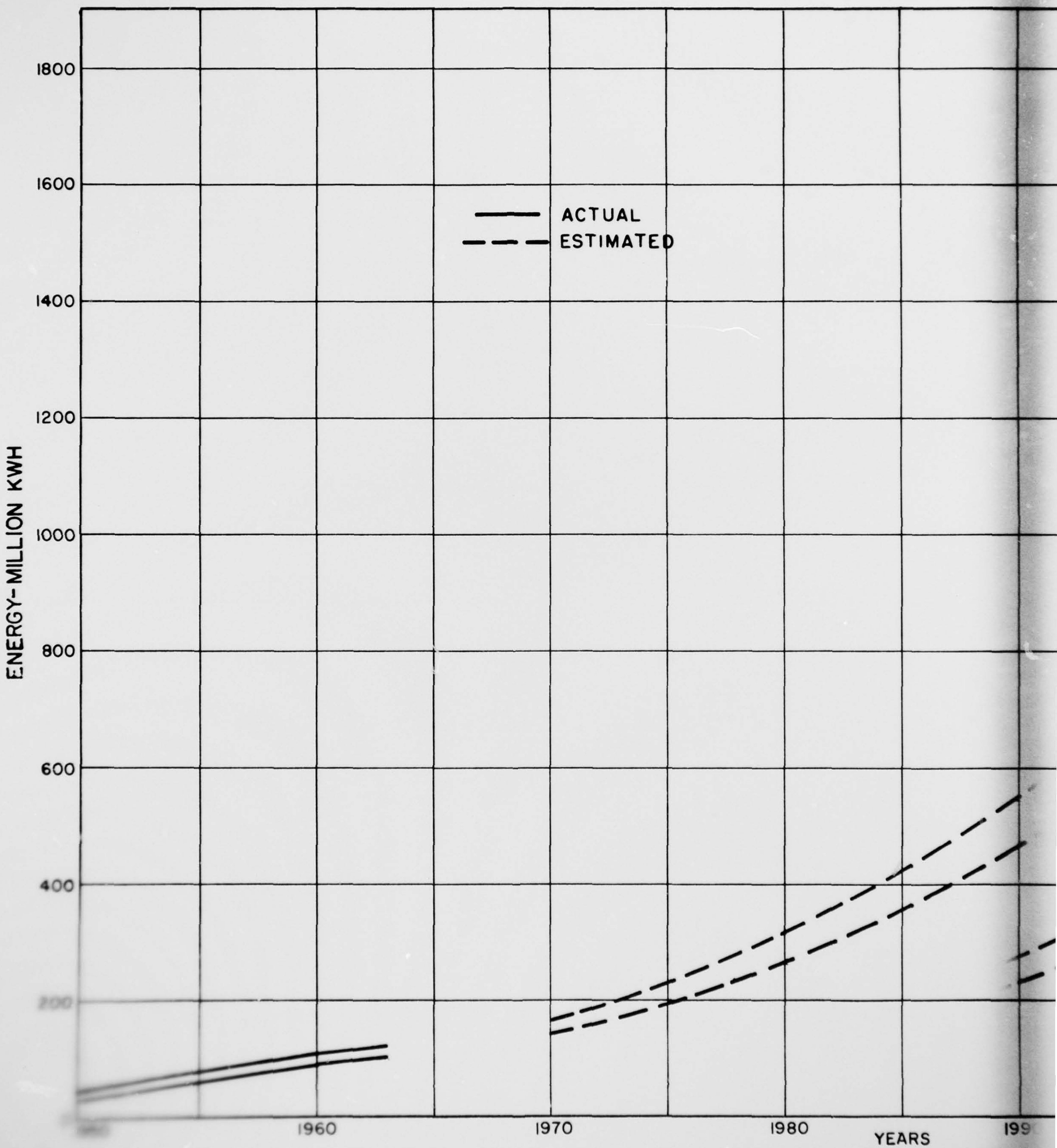
7
Monongahela
River
W. VA
RIVER
Kanawha
River
HUNTINGTON
PSA
19
PSA
10
River
New
River
VA.
N. CAR.
LEGEND
STATE BOUNDARY
OHIO RIVER DRAINAGE BASIN BOUNDARY
ELECTRIC UTILITY MARKET AREA BOUNDARY
POWER SUPPLY AREA BOUNDARY
12
F.P.C. POWER SUPPLY AREA
NOTE:
POWER SUPPLY AREA 19 LIES WHOLLY WITHIN MARKET AREA ALL OTHERS ARE ONLY PARTIALLY INCLUDED
20 0 20 40
Scale in miles
FEDERAL POWER COMMISSION
OHIO RIVER BASIN STUDY
POWER SUPPLY AREAS
IN
ELECTRIC UTILITY MARKET AREA
JULY 1965

EXHIBIT NO. 1



1800
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1000
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ENERGY-MILLION KWH
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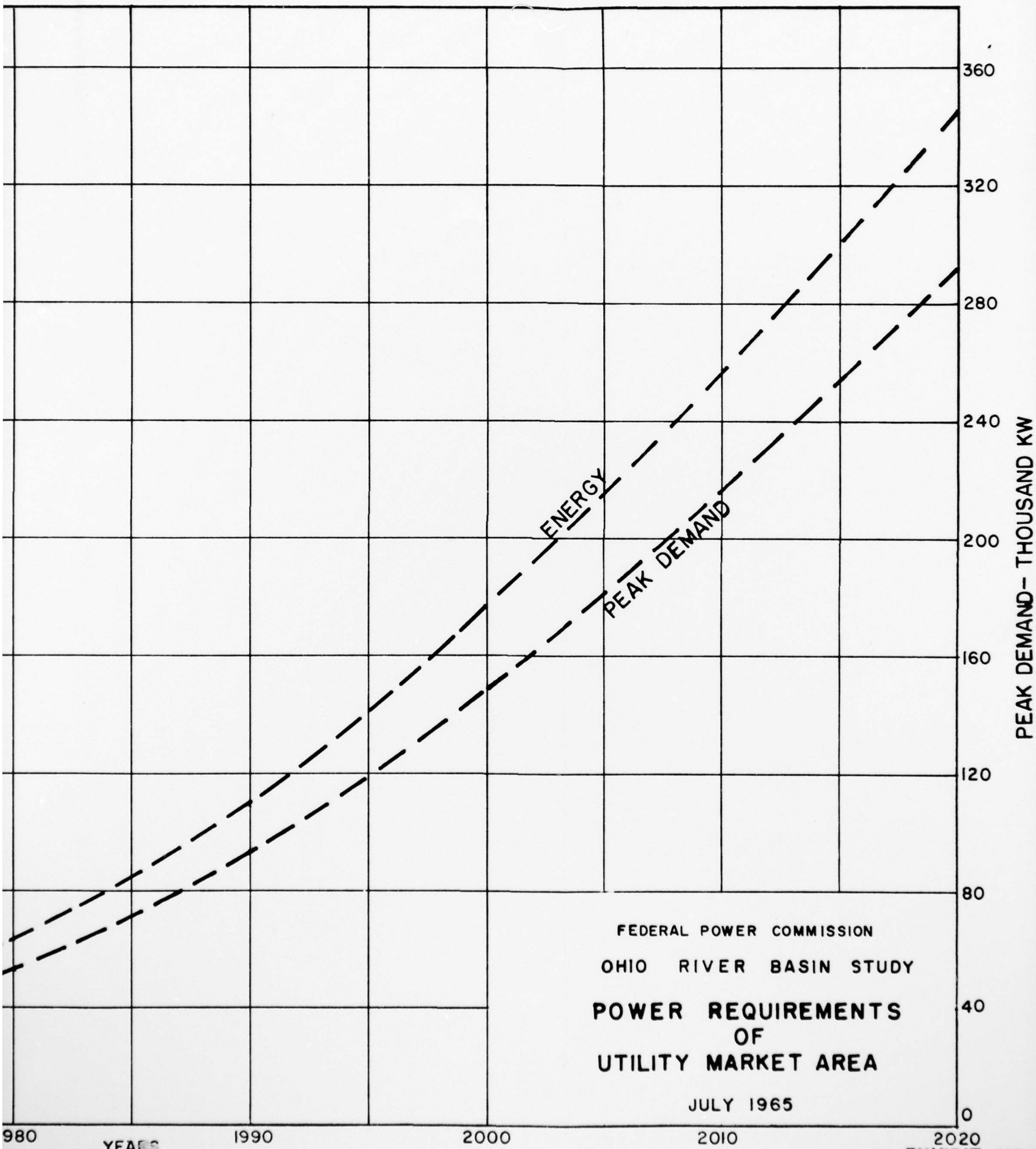
1970
1980
YEARS



360
320
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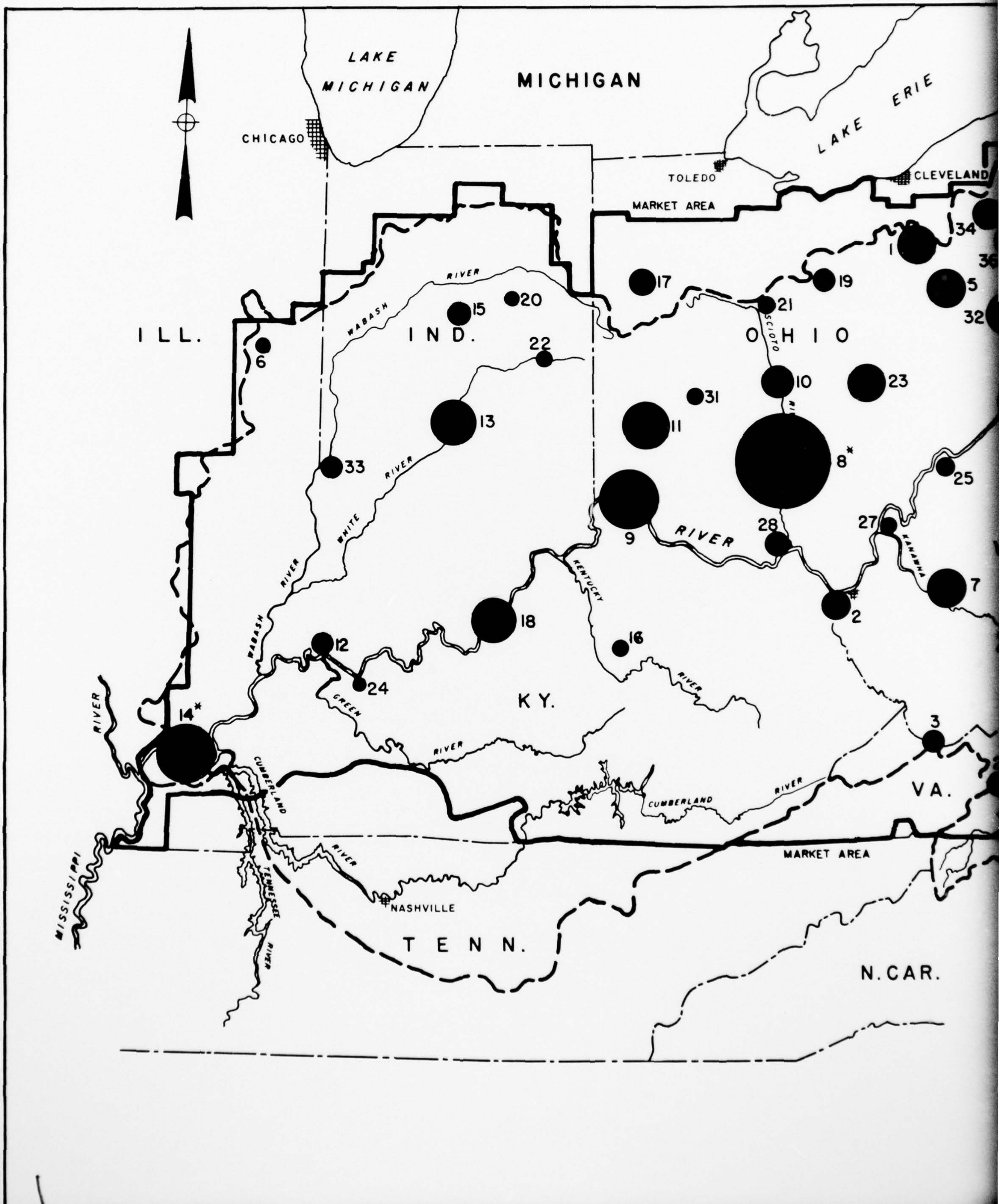
PEAK DEMAND- THOUSAND KW
ENERGY
PEAK DEMAND
980
YEARS
1990
2000
2010
2020
FEDERAL POWER COMMISSION
OHIO RIVER BASIN STUDY
POWER REQUIREMENTS
OF
UTILITY MARKET AREA
JULY 1965

EXHIBIT NO. 2



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TOLEDO
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KY.
VA.
TENN.
N. CAR.
WABASH RIVER
WHITE RIVER
SCIOTO RIVER
RIVER
KENTUCKY RIVER
KANAWHA
GREEN RIVER
CUMBERLAND RIVER
TENNESSEE RIVER
MISSISSIPPI RIVER
NASHVILLE
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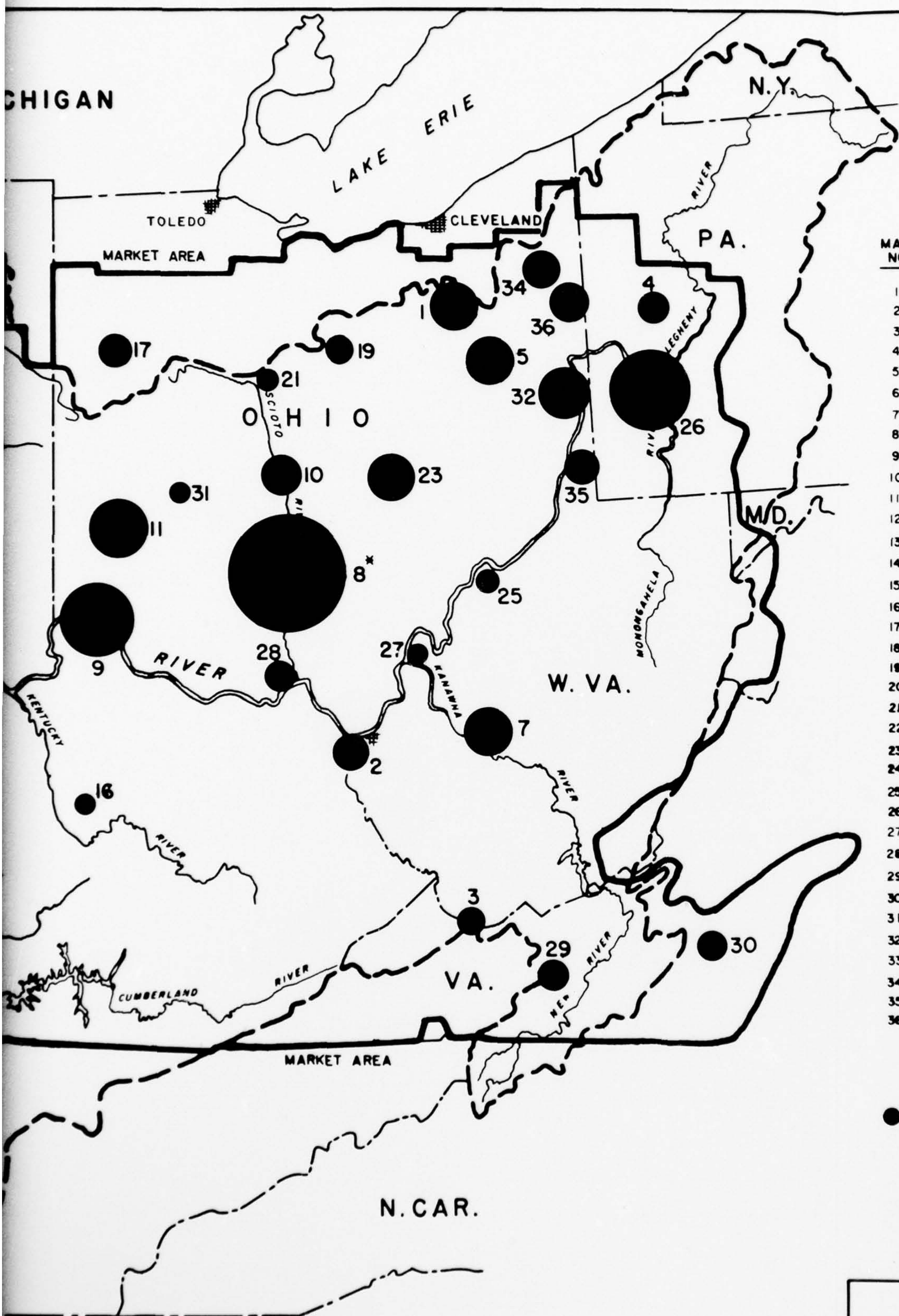


MAP NO.	LOAD CONCENTRATIONS	1963 ENERGY REQUIREMENTS (GIGAWATT HRS.)
1	AKRON, OHIO	2,700
2	ASHLAND, KY-HUNTINGTON, W.VA.	1,480
3	BLUEFIELD, VA-WELCH, W.VA.	890
4	BUTLER, PA.	1,150
5	CANTON, OHIO	2,320
6	CHAMPAIGN, ILL.	325
7	CHARLESTON, W.VA.	2,630
8*	CHILLICOTHE, OHIO	16,150
9	CINCINNATI, OHIO	6,215
10	COLUMBUS, OHIO	1,790
11	DAYTON, OHIO	4,000
12	EVANSVILLE, IND.	720
13	INDIANAPOLIS, IND.	3,760
14*	JOPPA, ILL.-PADUCAH KY.	6,520
15	KOKOMO, IND.	595
16	LEXINGTON, KY.	465
17	LIMA, OHIO	1,130
18	LOUISVILLE, KY.	3,700
19	MANSFIELD, OHIO	860
20	MARION, IND.	370
21	MARION, OHIO	440
22	MUNCIE, IND.	410
23	NEWARK-ZANESVILLE, OHIO	2,330
24	OWENSBORO, KY.	235
25	PARKERSBURG, W.VA.	540
26	PITTSBURGH, PA.	7,615
27	POINT PLEASANT, W.VA.	440
28	PORTSMOUTH, OHIO	890
29	PULASKI, VA.	1,150
30	ROANOKE, VA.	900
31	SPRINGFIELD, OHIO	450
32	STEUBENVILLE, OHIO-WEIRTON, W.VA.	3,120
33	TERRE-HAUTE, IND.	670
34	WARREN, OHIO	1,660
35	WHEELING, W.VA.	1,390
36	YOUNGSTOWN, OHIO	1,810

* AEC REQUIREMENTS

● AREA OF CIRCLE PROPORTIONAL TO ENERGY REQUIREMENTS

FEDERAL POWER COMMISSION

OHIO RIVER BASIN STUDY

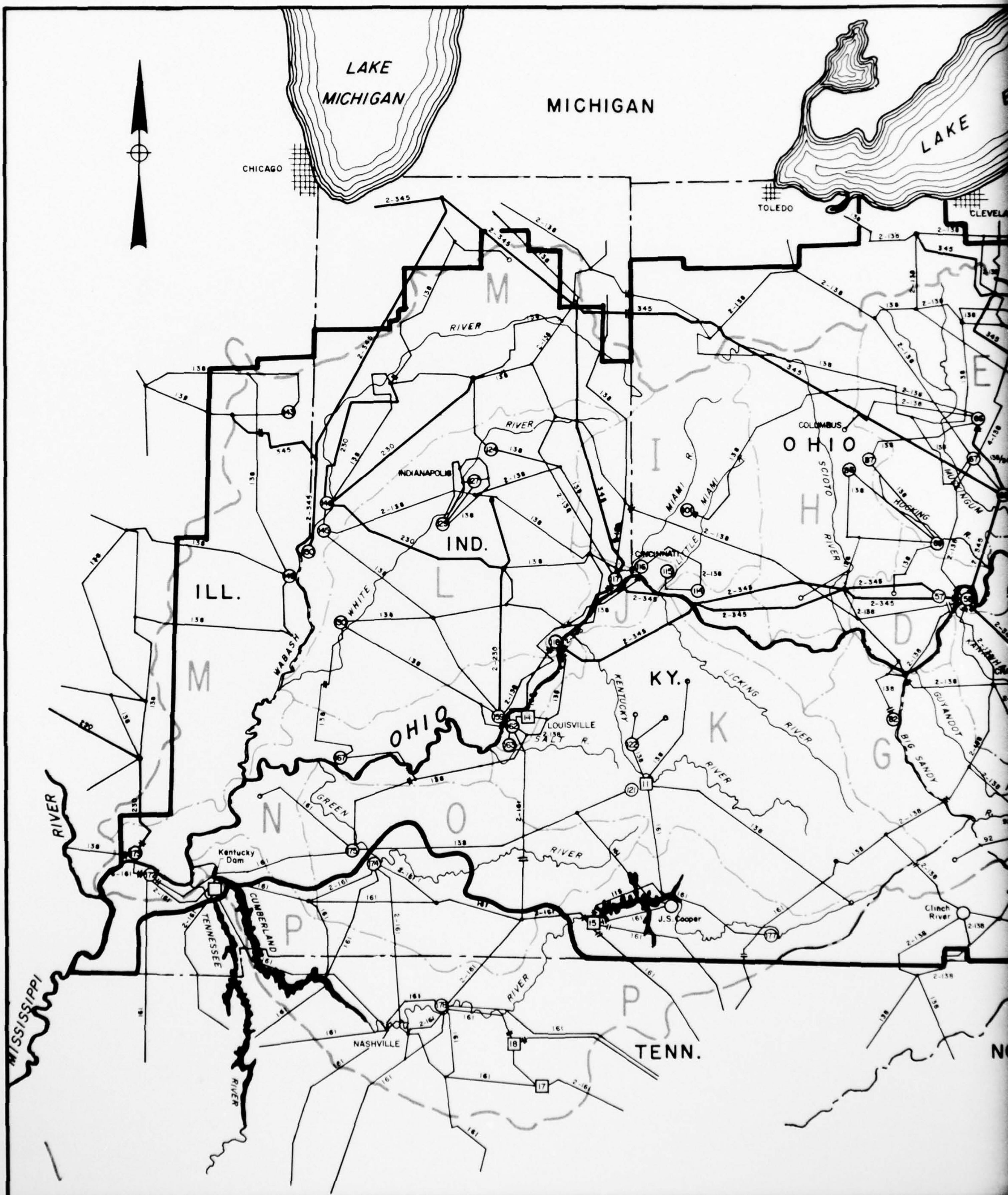
LOAD CONCENTRATIONS IN ELECTRIC UTILITY MARKET AREA

20 0 20 40

SCALE IN MILES

JULY 1965

EXHIBIT NO.3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TOLEDO
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COLUMBUS
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IND.
ILL.
CINCINNATI
LOUISVILLE
KY.
Kentucky Dam
J.S. Cooper
Clinch River
NASHVILLE
TENN.
MISSISSIPPI RIVER
WABASH
WHITE
OHIO
GREEN
CUMBERLAND
TENNESSEE
KENTUCKY
LICKING RIVER
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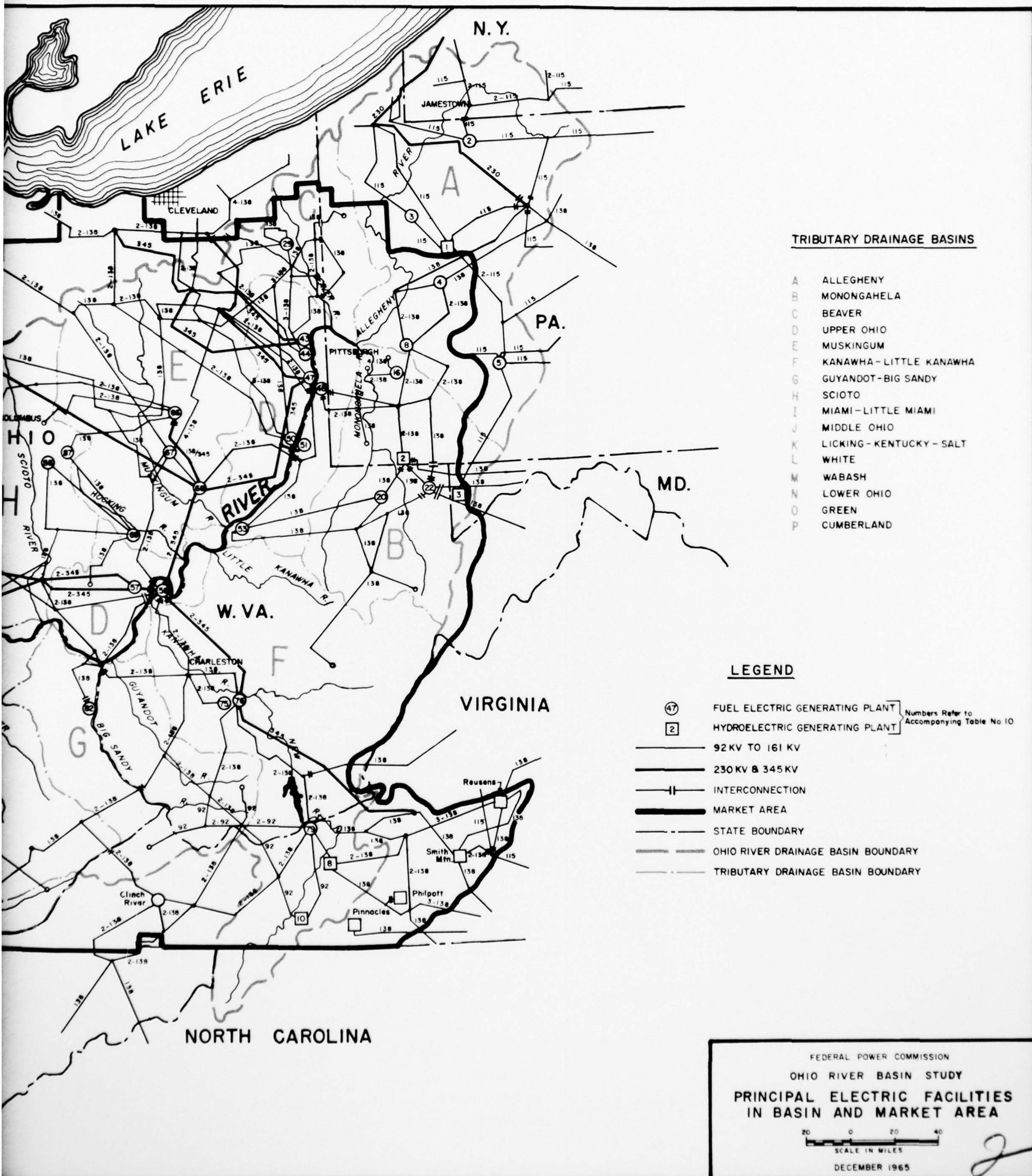
HOCKING
MUSKINGUM
BIG SANDY
GUYANDOT
SALT R.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PA.
MD.
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VIRGINIA
NORTH CAROLINA
CLEVELAND
PITTSBURGH
JAMESTOWN
CHARLESTON
COLUMBUS
Reusens
Smith Mtn.
Philpott
Pinnacles
Clinch River
ALLEGHENY RIVER
MONONGAHELA R.
MUSKINGUM R.
HOCKING R.
SCIOTO RIVER
LITTLE KANAWHA R.
KANAWHA R.
GUYANDOT R.
BIG SANDY R.
RIVER
TRIBUTARY DRAINAGE BASINS
A ALLEGHENY
B MONONGAHELA
C BEAVER
D UPPER OHIO
E MUSKINGUM
F KANAWHA - LITTLE KANAWHA
G GUYANDOT - BIG SANDY
H SCIOTO
I MIAMI - LITTLE MIAMI
J MIDDLE OHIO
K LICKING - KENTUCKY - SALT
L WHITE
M WABASH
N LOWER OHIO
O GREEN
P CUMBERLAND
LEGEND
47 FUEL ELECTRIC GENERATING PLANT
2 HYDROELECTRIC GENERATING PLANT
Numbers Refer to Accompanying Table No 10
92 KV TO 161 KV
230 KV & 345 KV
INTERCONNECTION
MARKET AREA
STATE BOUNDARY
OHIO RIVER DRAINAGE BASIN BOUNDARY
TRIBUTARY DRAINAGE BASIN BOUNDARY
FEDERAL POWER COMMISSION
OHIO RIVER BASIN STUDY
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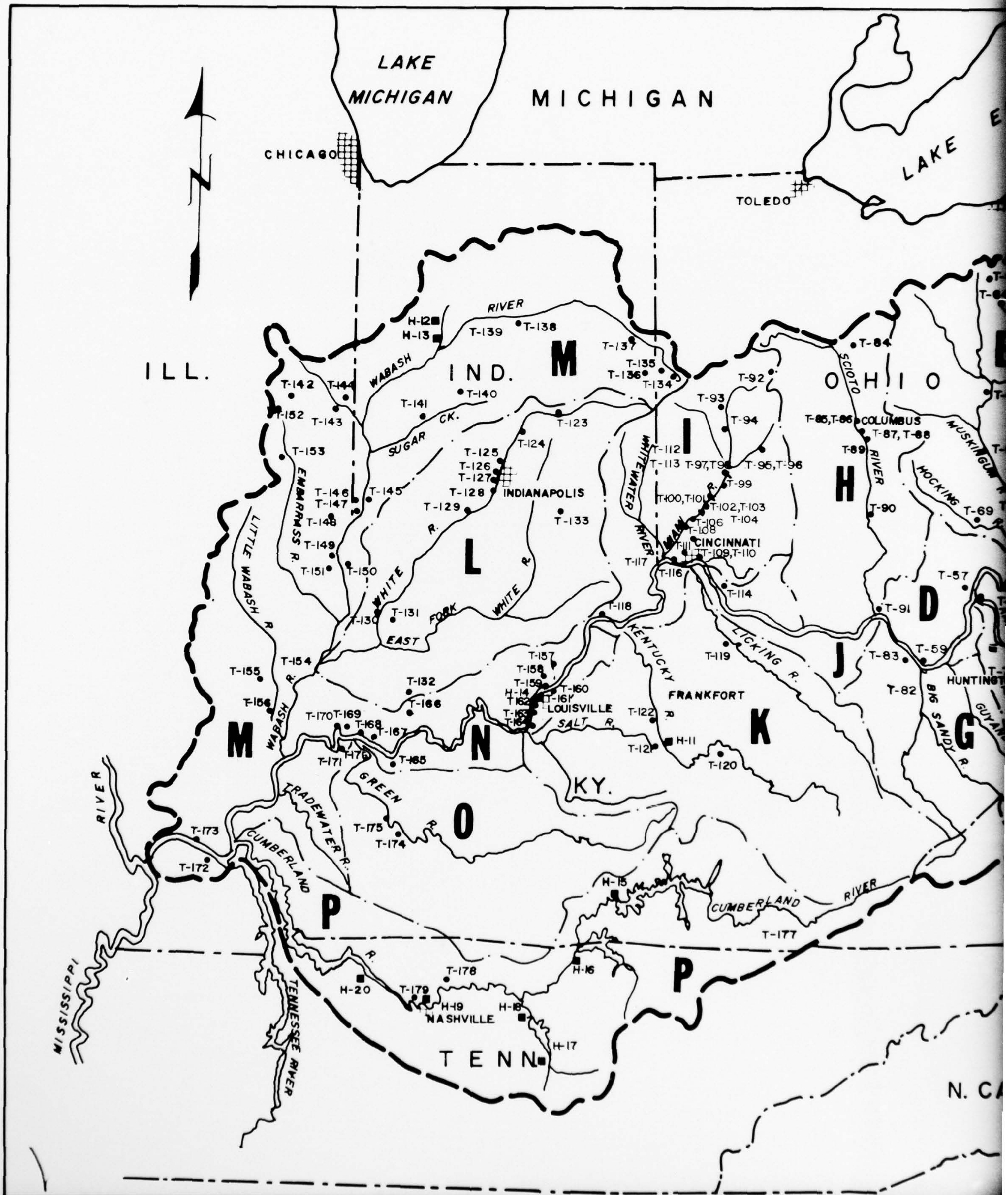
SCALE IN MILES
DECEMBER 1965

EXHIBIT NO. 4



LAKE MICHIGAN
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TOLEDO
LAKE E
ILL.
IND.
OHIO
KY.
TENN.
N. C
INDIANAPOLIS
CINCINNATI
COLUMBUS
LOUISVILLE
FRANKFORT
NASHVILLE
HUNTING
M
L
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O
P
WABASH RIVER
SUGAR CK.
WHITE R.
EAST FORK WHITE R.
EMBARRASS R.
LITTLE WABASH R.
WABASH R.
WHITEWATER RIVER
MIAMI R.
SCIOTO RIVER
HOCKING R.
MUSKINGUM R.
LICKING R.
KENTUCKY R.
SALT R.
GREEN R.
TRADEWATER R.
CUMBERLAND R.
CUMBERLAND RIVER
TENNESSEE RIVER
MISSISSIPPI RIVER
BIG SANDY R.
GUYAN
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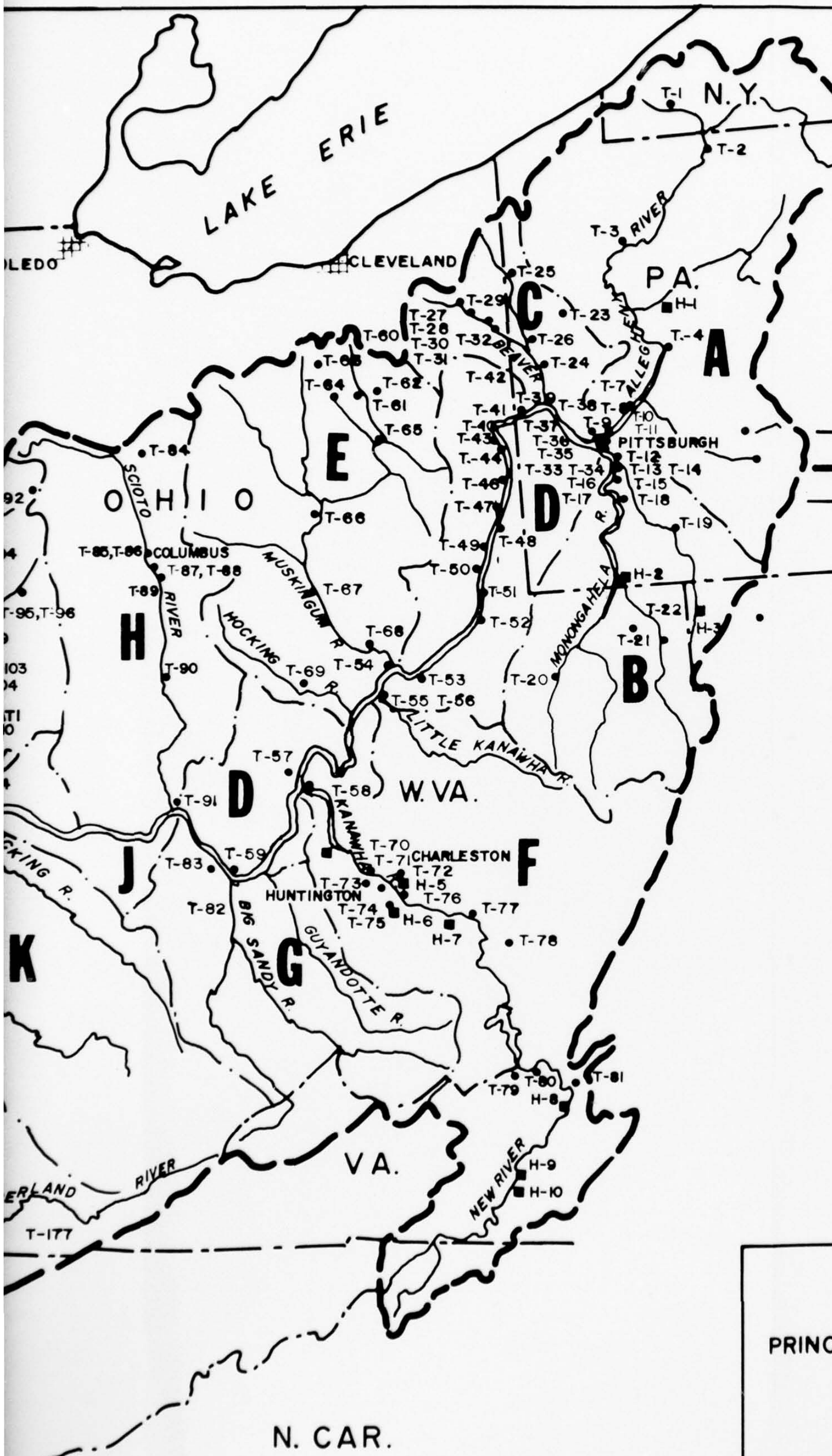

LEGEND

- ■ HYDROELECTRIC, GENERATING PLANT
- • FUEL ELECTRIC GENERATING PLANT
- —·— STATE BOUNDARY
- ▬ ▬ OHIO RIVER DRAINAGE BASIN BOUNDARY
- — · — TRIBUTARY DRAINAGE BASIN BOUNDARY

NOTE:
NUMBERS REFER TO ACCOMPANYING TABLE NO. 10. ONLY PLANTS 5,000 KW & OVER SHOWN ON MAP.

TRIBUTARY DRAINAGE BASINS

A	ALLEGHENY
B	MONONGAHELA
C	BEAVER
D	UPPER OHIO
E	MUSKINGUM
F	KANAWHA-LITTLE KANAWHA
G	GUYANDOTTE, BIG SANDY
H	SCIOTO
I	MIAMI-LITTLE MIAMI
J	MIDDLE OHIO
K	LICKING-KENTUCKY-SALT
L	WHITE
M	WABASH
N	LOWER OHIO
O	GREEN
P	CUMBERLAND

FEDERAL POWER COMMISSION
OHIO RIVER BASIN STUDY

PRINCIPAL ELECTRIC GENERATING FACILITIES

OHIO RIVER BASIN
20 0 20 40
SCALE IN MILES
JULY 1965

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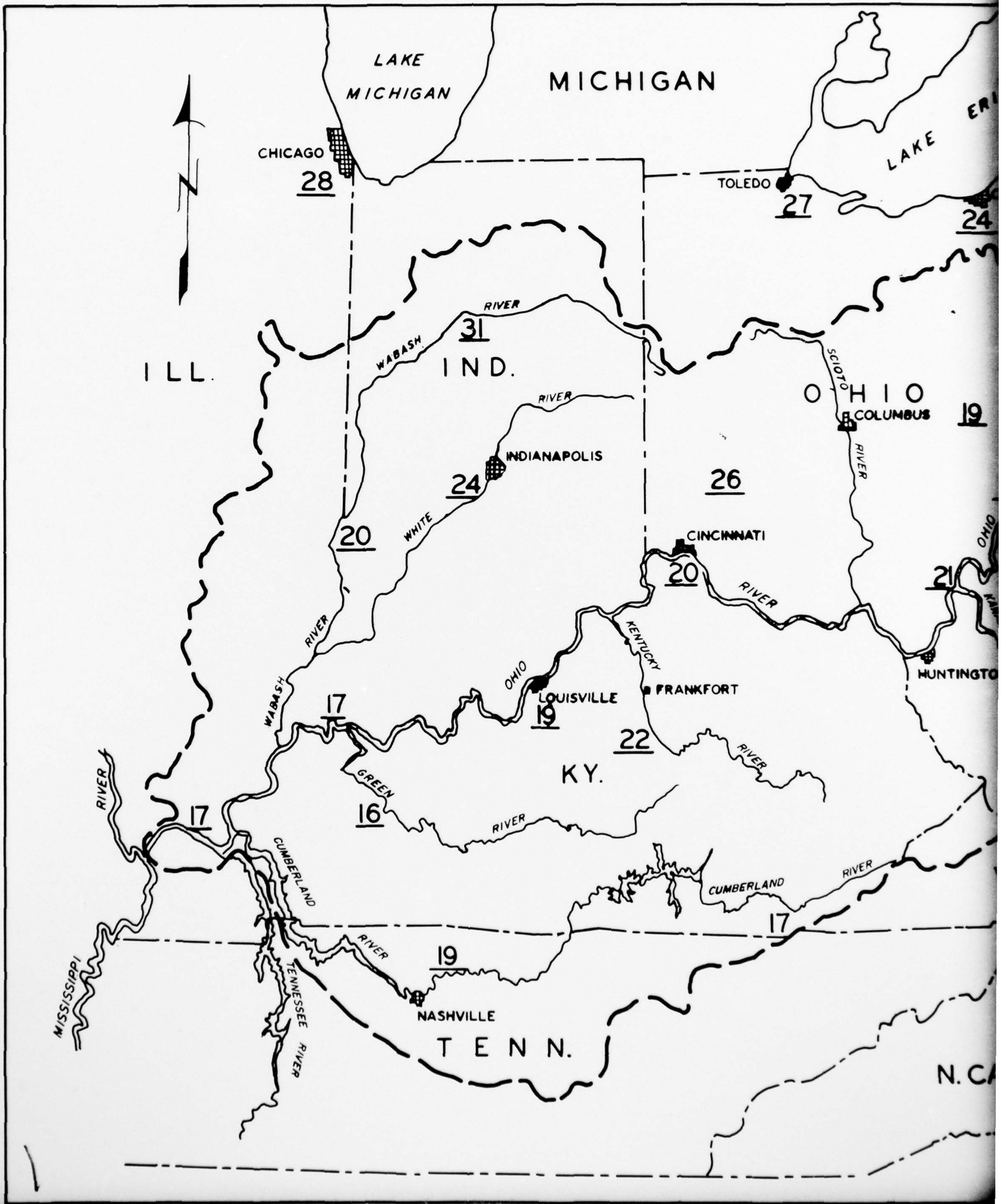
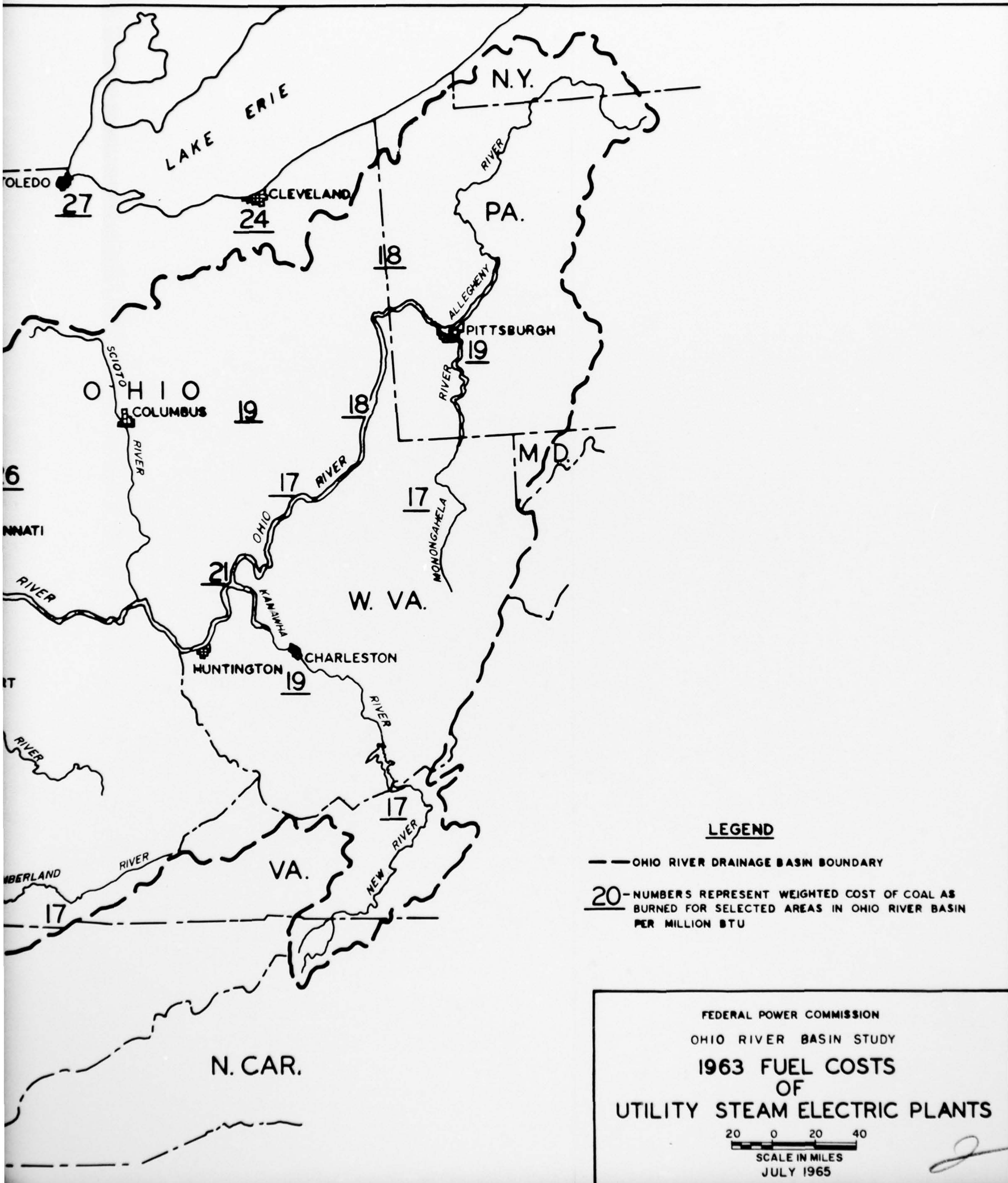
EXHIBIT NO. 5



LAKE MICHIGAN
MICHIGAN
LAKE ERI
CHICAGO
28
TOLEDO
27
24
31
RIVER
WABASH
ILL.
IND.
OHIO
SCIOTO
RIVER
COLUMBUS
19
INDIANAPOLIS
24
26
WHITE
20
CINCINNATI
20
RIVER
21
OHIO
KENTUCKY
HUNTINGTO
OHIO
LOUISVILLE
19
FRANKFORT
WABASH
RIVER
17
22
KY.
GREEN
16
RIVER
RIVER
17
CUMBERLAND
CUMBERLAND
RIVER
17
RIVER
19
MISSISSIPPI
TENNESSEE
RIVER
NASHVILLE
TENN.
N.CA



FEDERAL POWER COMMISSION

OHIO RIVER BASIN STUDY

1963 FUEL COSTS OF UTILITY STEAM ELECTRIC PLANTS

JULY 1965